САОБРАЋАЈНИ ИНСТИТУТ ЦИП д.о.о.
11000 БЕОГРАД, НЕМАЊИНА 6/IV
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CHINA RAILWAY DESIGN CORPORATION
КОСТЕ РАЦИНА 166, 11000 БЕОГРАД

2/2.1.6.2 TITLE PAGE

	2/2.6.2 DESIGN OF ALIGNMENT OF RAILWAY LINE AND STATIONS – SUBSTRUCTURE AND SUPERSTRUCTURE
Investor:	„Serbian Railway Infrastructure" JSC Nemanjina 6/IV, Belgrade
Employer:	Consortium: China Railway International Corporation Ltd. (CRIC) China Communication Construction Company Ltd. (CCCC)
Object:	Belgrade – Subotica – State Border (Kelebija) Railway Line, Section Novi Sad – Subotica – State Border (Kelebija), in Novi Sad, Kisač, Stepanovićevo, Zmajevo, Vrbas, Lovćenac, Mali Iđoš, Bačka Topola, Žednik, Naumovićevo and Subotica, C.M. Novi Sad I, C.M. Novi Sad IV, C.M. Kisač, C.M. Rumenka, C.M. Stepanovićevo, C.M. Čenej, C.M. Bačko Dobro Polje, C.M. Vrbas - ATAR, C.M. Vrbas - grad, C.M. Zmajevo, C.M. Kucura, C.M. Lovćenac, C.M. Mali Iđoš, C.M. Feketić, C.M. Bačka Topola, C.M. Bačka Topola - Grad, C.M. Mali Beograd, C.M. Bikovo, C.M. Donji Grad, C.M. Žednik, C.M. Novi Grad, C.M. Palić, C.M. Stari Grad, on cadastral parcels according to the list attached to Main Notebook
Type of technical documentation:	**DFC –** Design for construction
Name and designation part of project:	**DESIGN OF ALIGNMENT OF RAILWAY LINE AND STATIONS – SUBSTRUCTURE AND SUPERSTRUCTURE** **2/2.6.2 DESIGN OF SUPERSTRUCTURE FOR BRIDGE STRUCTURES LONGER THAN 40M SECTION RUMENKA EXIT -VRBAS NOVA PASSENGER ENTRY**
For construction / execution of works:	New construction
Designer:	Saobraćajni institut CIP, d.o.o. Nemanjina 6/IV,Beograd 351-02-03602/2020-09
Representative of designer:	Managing Director: Milutin Ignjatović, Grad. Eng.
Signature:	
Responsible designer:	Dragana Jokanović, Grad. Civ. Eng.
Signature:	License number: 315 1404 03 Dragana Jokanović Digitally signed by Dragana Jokanović Date: 2021.12.21 13:49:23 +01'00'
Number of designation part of project:	2020-250-CAO-2/2.6.2
Place and date:	Belgrade, December 2021.

2/2-6.2.2. TABLE OF CONTENTS

DESIGN OF PERMANENT WAY ON THE BRIDGE STRUCTURES LONGER THAN 40 M

Rumenka exit- Vrbas entry section

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2/2.6.2.3 РЕШЕЊЕ О ОДРЕЂИВАЊУ ОДГОВОРНОГ ПРОЈЕКТАНТА

На основу Члана 128, Закона о планирању и изградњи ("Службени гласник РС", бр. 72/09, 81/09-исправка, 64/10- одлука УС, 24/11, 121/12, 42/13-одлука УС, 50/13-одлука УС, 98/13-одлука УС, 132/14, 145/14, 83/2018, 31/2019, 37/2019 - др.закон 9/20 и 52/21) и одредби Правилника о садржини, начину и поступку израде и начину вршења контроле техничке документације према класи и намени објеката ("Службени гласник РС", бр. 73/2019) као:

О Д Г О В О Р Н И П Р О Ј Е К Т А Н Т

за израду **ПРОЈЕКТА ТРАСЕ ПРУГЕ И СТАНИЦА - ДОЊИ И ГОРЊИ СТРОЈ**
2/2.6.2 Пројекат горњег строја за мостовске конструкције дужине преко 40м, деоница Руменка (излаз) – Врбас Нова путничка (улаз), који је део ПЗИ - Пројекта за извођење за изградњу пруге Београд - Суботица државна граница (Келебија), **ДЕОНИЦА ПРУГЕ НОВИ САД -СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)**, у Новом Саду, Кисачу, Степановићеву,Змајеву, Врбасу, Ловћенцу, Малом Иђошу, Бачкој Тополи, Жеднику, Наумовићеву иСуботици, К.О. Нови Сад I, К.О. Нови Сад IV, К.О. Кисач, К.О. Руменка, К.О.Степановићево, К.О. Ченеј, К.О. Бачко Добро Поље, К.О. Врбас, К.О. Врбас - град, К.О.Змајево, К.О. Куцура, К.О. Ловћенац, К.О. Мали Иђош, К.О. Фекетић, К.О. Бачка Топола,К.О. Бачка Топола - Град, К.О. Мали Београд, К.О. Биково, К.О. Доњи Град, К.О. Жедник,К.О. Нови Град, К.О. Палић, К.О. Стари Град, на катастарским парцелама према списку приложеном у Главној свесци, одређује се:

Драгана Јокановић, дипл. грађ. инж. _____ 315 1404 03

Пројектант:	САОБРАЋАЈНИ ИНСТИТУТ ЦИП д.о.о., Београд Немањина 6/IV
Одговорно лице/заступник:	Генерални директор: Милутин Игњатовић, дипл. инж.
	Потпис:
Број техничке документације:	2020-250-САО-2/2.6.2
Место и датум:	Београд, децембар 2021.год

2/2.6.2.4 ИЗЈАВА ОДГОВОРНОГ ПРОЈЕКТАНТА

Одговорни пројектант **ПРОЈЕКТА ТРАСЕ ПРУГЕ И СТАНИЦА-ДОЊИ И ГОРЊИ СТРОЈ-2/2.6.2 Пројекат горњег строја за мостовске конструкције дужине преко 40м – деоница Руменка (излаз) – Врбас Нова путничка (улаз),** који је део ПЗИ - Пројекта за извођење за изградњу пруге Београд - Суботица државна граница (Келебија), **ДЕОНИЦА ПРУГЕ НОВИ САД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)**, у Новом Саду, Кисачу,Степановићеву, Змајеву, Врбасу, Ловћенцу, Малом Иђошу, Бачкој Тополи, Жеднику,Наумовићеву и Суботици, К.О. Нови Сад I, К.О. Нови Сад IV, К.О. Кисач, К.О. Руменка,К.О. Степановићево, К.О. Ченеј, К.О. Бачко Добро Поље, К.О. Врбас, К.О. Врбас - град,К.О. Змајево, К.О. Куцура, К.О. Ловћенац, К.О. Мали Иђош, К.О. Фекетић, К.О. Бачка Топола, К.О. Бачка Топола - Град, К.О. Мали Београд, К.О. Биково, К.О. Доњи Град, К.О. Жедник, К.О. Нови Град, К.О. Палић, К.О. Стари Град, на катастарским парцелама према списку приложеном у Главној свесци:

Драгана Јокановић, дипл. грађ. инж.

И З Ј А В Љ У Ј Е М

1. да је пројекат у свему у складу са издатим Локацијским условима:

-бр. ROP-MSGI-7141-LOC-1/2020, Заводни број: 350-02-00109/2020-14 од 08.05.2020,

-бр. ROP-MSGI-931-LOCA-3/2020, Заводни број: 350-02-00192/2020-14 од 29.05.2020;

-бр. ROP-MSGI-28188-LOCAH-6/2021, Заводни број: 350-02-01883/2021-07 од 30.09.2021. год.

2. да је пројекат у свему у складу са пројектом за грађевинску дозволу и издатом грађевинском дозволом:

-бр. ROP-MSGI-27315-CPI-2/2021, Заводни број: 351-02-03590/2021-07 од 26.10.2021.год.

3. да је пројекат израђен у складу са Законом о планирању и изградњи, прописима, стандардима и нормативима из области изградње објеката и правилима струке;

4. да је пројекат у свему у складу са начинима за обезбеђење испуњења основних захтева за објекат прописаних елаборатима и студијама.

Одговорни пројектант:	Драгана Јокановић, дипл. грађ. инж.
Број лиценце:	315 1404 03
	Потпис:
Број техничке документације:	2020-250-САО-2/2.6.2
Место и датум:	Београд, децембар 2021.год.

2/2-6.2.5. TEXTUAL DOCUMENTATION

2/2-6.2.5.1 TECHNICAL DESCRIPTION

2/2-6.2.5.1 Design of permanent way for bridge structures longer than 40 m section Rumenka Exit – Vrbas Nova passenger entry

Technical description

Based on the calculations of vehicle/track/bridge interaction made by CRDC responsible designer for bridge structures, the Design for construction of permanent way for bridge structures longer than 40 m was completed as a part of the Building permit design for modernization (reconstruction and new construction) of the Belgrade – Subotica - State border (Kelebija) railway line, Novi Sad - Subotica - State border (Kelebija) section.

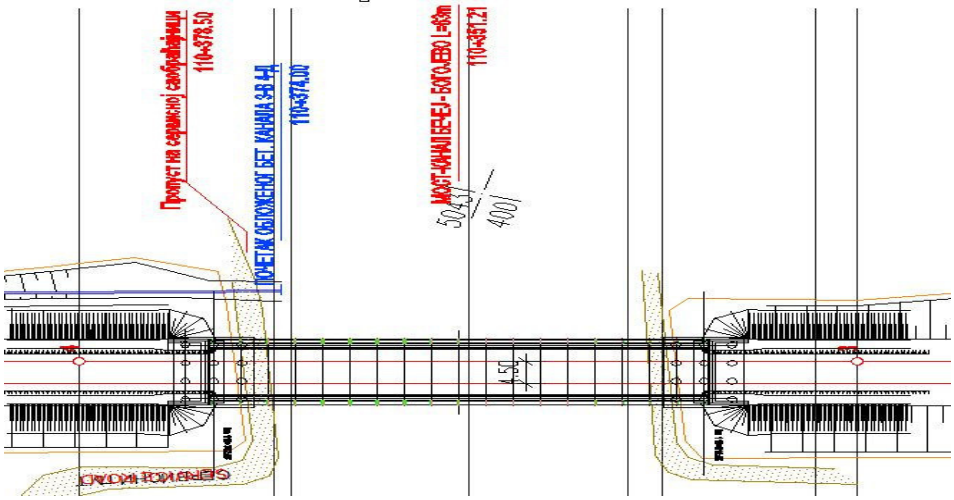
Bridge at km 110+351.21 (R.T.)

On this section there one bridge over 40m long (at km 110+351.21 R.T.)

This Design includes permanent way on the bridge structures and along 10.4 m length before and behind the bridge structures (from the beginning to the end of guard rail) and cost estimates for transition sleepers and elastomeric rail pads.

New double-track bridge is designed at km 110+351,21 R.T., over the Becej-Bogojevo canal and it is a part of newly designed main railway line situated on the section Rumenka Exit – Vrbas Nova passenger entry.The bridge structure is treated in Volume 2/1-1.20 Design of the bridge at km 110+351,26. The bridge structures shall be provided with elastomer mats under ballast and corresponding cost estimate is included in the Design of bridge structures.

Center-to-center distance between tracks is 4.75 m. 4,50м. Tracks on the bridge are straight. The tracks have a downgradient of 4.0‰. Maximum speed on the bridge is 200km/h.



Permanent way on the bridge structure is designed according to newly designed permanent way on open line.

- Types of running rail and guard rail: 60E1, R260 steel grade in accordance with SRPS EN 13674-1
- Continuously welded running rails
- Nominal track gauge on straight sections and in curves is 1435 mm, allowable deviations from the designed track gauge values in accordance with SRPS EN13231-1
- Inclination of the axis of symmetry of laid rails towards track centerline in cross section is 40:1
- Rail fastening system in accordance with SRPS EN 13481:2013

- Monobloc prestressed concrete sleepers with flat top surfaces, 2.60 m long, at 60 cm center-to-center spacing on the bridge and in the length of 10.4 m before and behind the bridge Concrete sleepers with elastomeric pads shall be placed in transition zones before and behind the bridge for achieving linear change of the base rigidity in accordance with EN 16730 in order to reduce maintenance costs. The transition zone length was calculated based on 0.5 s of train speed.
- Ballast made of crushed stone, class 1 in accordance with SRPS EN 13450
- Thickness of ballast under the sleepers before and behind the bridge is 30 cm minimum
- Thickness of ballast under the sleepers on the bridge structures is 35 cm minimum

The rail length proposed in the design is 50 m and 25 m for guard rails. Longer running rails can also be used. The maximum guard rail length is 30 m. The rails shall be welded by electric resistance welding process, but aluminothermic welding process can also be used (final welding of rails in track and welding of expansion joints). The Design specifies that electric resistance welding process shall be used to weld rails into 300 m sections.

Due to different heights of railway sleepers (h= 210 mm) and flat concrete sleepers on bridges (h=193 mm), transition concrete sleepers (h=200 mm) will be placed along 15 m length between concrete track sleepers and concrete sleepers on bridges to enable gradual change of height. Type of fastening system on transition concrete sleepers is same as fastening system on railway sleepers and therefore it was not estimated in this design.

60E1 guard rails with elastic fastening system shall be laid on bridge structures and along 10.4 m length before and behind the bridge to serve as protection against harmful effects of train derailment. Flat concrete sleepers shall support running and guard rails that will rest on double steel base plates.

Layout drawing shows the bridge of 63 m span with rocker bearing on pier S1 and fixed bearing on pier S2Total length of the bridge structure is 63 m.

Elastomeric pads under 2.60 m long concrete sleepers shall be placed along 27.20 m length before and behind bridge in order to increase the base elasticity and enable gradual change of rail deflection when ruling vehicle passes from the track on embankment to transition structure as well as from transition structure to bridge structure.
Before the bridge elastomeric pads shall be placed before concrete transition sleepers along 1.8 m length, under concrete track transition sleepers along 15 m and behind concrete track transition sleepers along 10.4 m and behind the bridge elastomeric pads shall be placed under all concrere sleepers for track expansion joint and under concrete track transition sleepers along 15 m.

Since the bridge expansion length exceeds 40 m, the CRDC designer calculated the track-bridge interaction and it was taken from Volume No. 2/1-1.20 Design of the bridge at km 110+351.26.

The calculations of vehicle/track/bridge interaction is included in the Numerical documentation of this Volume.

The calculation of the interaction has shown that it is necessary to install a rail expansion joint of a= ±100mm minimum capacity above the end rocker bearing (pier S2) on both tracks at km 110+351,26 R.T..

The calculation was made under assumption that maximum longitudinal resistance during elastic rail movement through elastic fastening system is 30 kN/m, which corresponds to 9 kN longitudinal resistance force.

The calculation has shown that track is stable in horizontal plane and that compressive stress, tensile stress, maximum relative movements, absolute movements and horizontal movements due to turned ends of bridge superstructure under high train vertical load are within permitted limits when expansion joint of a= ±100mm.

INVESTMENT VALUE OF WORKS

The value of works was estimated in the Priced Bill of Quantities. The investment value of works was determined based on the quantity measurement notes and unit prices of items.
The Priced Bill of Quantities includes all works envisaged in this design. Type and description of works are provided according to parameters for construction of new railway lines which are currently applied in constructing this type of facility.
The Priced Bill of Quantities was prepared based on data processed in the office, layout plans, computer processed data and average prices for this type of works according to the provided description of items.
The unit prices are expressed in dinars (RSD) based on average prices from the tender and technical documentation for similar facilities and type of works. The Priced Bill of Quantities specified the value of works on permanent way as well as the summary of works by types for this design.

GRAND SUMMARY

2/2.04.00	PERMANENT WAY - PROCUREMENT OF MATERIALS	21 245 198.00
2/2.05.00	PERMANENT WAY-MATERIAL HANDLING	331 964.00
2/2.06.00	PERMANENT WAY-WORKS ON THE SUPERSTRUCTURE	6 410 250.00
2/2.07.00	PERMANENT WAY-TRACKSIDE EQUIPMENT	45 600.00

TOTAL (RSD): **28 033 012.00**

During the works execution, all works related to signaling-interlocking system, telecommunication system, overhead catenary system, water supply system and mechanical installations must be synchronized with earthworks required for construction of track substructure.

RESPONSIBLE DESIGNER:

Dragana Jokanović, Grad. Civ. Eng.

License No. 315 1404 03 issued by
the Serbian Chamber of Engineers

2/2-6.2.6. NUMERICAL DOCUMENTATION

2/2-6.2.6.1 QUANTITIES MEASUREMENT NOTES

Evidence for the upper machine for bridge structures over 40m long
Section Rumenka exit - Vrbas Nova passenger entry

Bridge on km 110+351.21 R.T.

2/2.04.00 PERMANENT WAY – PROCUREMENT OF MATERIALS

2/2.04.01-1 **RAIL TYPE 60E1.**

Left main track:
63+2x10,4..... L=83,80m
Right main track:
63+2x10,4..... L=83,80m

Protective rail:
Left main track:
63+2x10,4..... L=83,80m
Right main track:
63+2x10,4..... L=83,80m
(83,80x4)m x 2 x 60.21kg/m…….....…=40.364,78kg…....….=40.36t

2/2.04.02-2 **CONCRETE SLEEPERS ON BRIDGES, 2.60m LONG**

with a flat upper surface on which they are mounted via double steel base plates

driving and safety rail

83,80x2 / 0.6.....=280pcs

2/2.04.02-6 **TRANSITION CONCRETE SLEEPERS, 2.60m LONG**

Left and right track of the main line in front of and behind the concrete thresholds on the bridges
2x15x2 / 0.6.....=100pcs

2/2.04.02-1a **ELASTOMERIC RAIL PADS UNDER CONCRETE SLEEPERS, 2.60m LONG**

Before the bridge before concrete transition sleepers along 1.8 m length

2x1.8/0.6.....=6 pcs

2/2.04.02-2a **ELASTOMERIC PADS UNDER TRANSITION CONCRETE SLEEPERS, 2.60m LONG**

Before the bridge under concrete track transition sleepers along 15 m .....2x15/0.6=50 pcs

Behind the bridge under concrete track transition sleepers along 15 m .....2x15/0.6=50 pcs

∑=100 pcs

2/2.04.02-3a **ELASTOMERIC RAIL PADS UNDER CONCRETE SLEEPERS ON BRIDGES, 2.60m LONG**

Below the concrete sleepers on the bridges on the part of the safety rail in front of the bridge, l=10.4m

2x10.4/0.6.....=36 pcs

2/2.04.02-5a **ELASTOMERIC PADS UNDER CONCRETE SLEEPERS FOR TRACK EXPANSION JOINTS, 2.60m LONG**
Under all concrere sleepers for track expansion joint
2x12.6/0.6.....=42 pcs

2/2.04.03-3 **FASTENING SYSTEM FOR RUNNING RAIL AND CHECK RAIL, TYPE 60E1**

.....=280 set

2/2.04.03-9 **JOINING PIECES FOR JOINTS IN CHECK RAILS ON BRIDGES**

(83,80/25 -1)x4.....=10set

2/2.04.04-2 **TRACK EXPANSION JOINTS**

1x2 .....=2pcs

2/2.04.05 **CRUSHED STONE, CATEGORY I**

4.80x83.80.....403m^3

2/2.04.06-1 **WELDING SET FOR AT WELDING OF 60E1 RAILS IN LONG RAIL LENGHTS**

Expansion joints:
4 x 2.....=8pcs

2/2.05.00 PERMANENT WAY – MATERIAL HANDLING

2/2.05.01 **RAIL UNLOADING**

.....= 40.36t

2/2.05.02 **UNLOADING OF CONCRETE SLEEPERS**

.....=380pcs

2/2.05.03 **UNLOADING OF ELASTIC TRACK FASTENINGS**

280 * 15..... =4200kg.....=4.20t

2/2.05.04-1 **UNLOADING OF TRACK EXPANSION JOINTS**

.....=2pcs

2/2.06.00 PERMANENT WAY - WORKS

2/2.06.04-1 **ASSEMBLY AND LAYING TRACK ON CONCRETE SLEEPERS, FIXING IT WITH ELASTIC TRACK FASTENINGS, RAIL TYPE 60E1**

83.8x2..... L=0.17km

2/2.06.06 **LAYING OF GUARD RAILS**

83.8x2.....L=0.17км

2/2.06.07 **INSTALLATION OF TRACK EXPANSION DEVICES** 2pcs

2/2.06.07-1 **MECHANIZED LEVELLING AND DYNAMIC STABILIZATION OF TRACK ON CONCRETE SLEEPERS, RAIL TYPE 60E1**..... L=0.17km

2/2.06.07-3-1 **MECHANIZED ALIGMENT OF EXPANSION JOINT**

.....2pcs

2/2.06.08-1 **ELECTRIC RESISTANCE WELDING OF 60E1 RAILS TO FORM CWR**

(83.80/ 50 +1) x 4 .....=12weld

2/2.06.08-5-1	**ALUMINOTHERMIC WELDING OF EXPANSION JOINTS IN CWR** 4x2.....=8weld
2/2.06.09-1	**STRESS RELIEF IN RAILS 60E1 WITH FINAL WELDING** ..... L=0.17km
2/2.06.09-4	**STRESS RELIEF IN EXPANSION DEVICES AND FINAL WELDING**.....=2pcs

2/2.07.00 PERMANENT WAY - EQUIPMENT

2/2.07.01 **PROCUREMENT AND PLACING OF MARKERS**

Long rail track control markings.....=4pcs

RESPONSIBLE DESIGNER:

Dragana Jokanović, Grad.Civ.Eng.

2/2-6.2.6.2 INVESTMENT VALUE OF PERMANENT WAY FOR THE BRIDGE STRUCTURE AT KM 110+351.21, 63 M LONG

САОБРАЋАЈНИ ИНСТИТУТ ЦИП д.о.о.
Немањина 6/IV, 11000 Београд

PRICED BILL OF QUANTITIES

2/2-6.2- Investment value of permanent way for the bridge structure at km 110+351,21 Д.К., L = 63m
2/2-6.2- Section Rumenka exit - Vrbas Nova passenger entry

Item	Description	MU	Quantity	Unit price (RSD)	Total (RSD)
			A	B	AxB
2/2.04.00	**PERMANENT WAY - PROCUREMENT OF MATERIALS**				
2/2.04.01-1	**RAIL TYPE 60E1.** The item includes the procurement and delivery to site of rails type 60E1, quality R260 according to EN13674 - 1 , length L=75 m. Measurement for payment per tonne of delivered rails. bridge at km 110+351,21 L=63м	t	40,36	125.000,00	5.045.598,00
2/2.04.02-2	**CONCRETE SLEEPERS ON BRIDGES, 2.60m LONG** The item includes procurement and delivery to site of flat concrete sleepers, 2.60m long for rail type 60E1 with quard rail and rail fastening system according to SRPS EN13481-2. Measurement and payment per piece. bridge at km 110+351,21 L=63м	pcs.	280	8.800,00	2.464.000,00
2/2.04.02-6	**TRANSITION CONCRETE SLEEPERS, 2.60m LONG** The item includes procurement and delivery to site of transition concrete sleepers,rail type 60 E1, L=2,60 m, Measurement and payment per piece.	pcs.	100	5.050,00	505.000,00
2/2-04.02-1a	**ELASTOMERIC RAIL PADS UNDER CONCRETE SLEEPERS, 2.60 m LONG** The item includes procurement, transport and delivery of elastic rail pads to concrete sleeper factory where they will be installed. Measurement and payment per each elastomeric rail pad. for concrete sleepers, 2.60m long	pcs.	6	3.000,00	18.000,00
2/2.04.02-2a	**ELASTOMERIC PADS UNDER TRANSITION CONCRETE SLEEPERS, 2.60m LONG** The item includes procurement, transport and delivery of elastic rail pads to concrete sleeper factory where they will be installed.	pcs.	100	3.000,00	300.000,00

Item	Description	MU	Quantity	Unit price (RSD)	Total (RSD)
			A	B	AxB
2/2-04.02-3a	**ELASTOMERIC RAIL PADS UNDER CONCRETE SLEEPERS, ON BRIDGES 2.60 m LONG** The item includes procurement, transport and delivery of elastic rail pads to concrete sleeper factory where they will be installed. Measurement and payment per each elastomeric rail pad. for concrete sleepers on bridges, 2.60m long	pcs.	36	3.000,00	108.000,00
2/2-04.02-5a	**ELASTOMERIC PADS UNDER CONCRETE SLEEPERS FOR TRACK EXPANSION JOINTS** The item includes procurement, transport and delivery of elastic rail pads to concrete sleeper factory where they will be installed. Measurement and payment per each elastomeric rail pad.	pcs.	42	3.000,00	126.000,00
2/2.04.03-3	**FASTENING SYSTEM FOR RUNNING RAIL AND CHECK RAIL FOR CONCRETE SLEEPERS AND RAIL TYPE 60E1.** The item includes procurement and delivery to site of rail fastenings for running rail and check rail type 60E1 for concrete sleepers according SRPS EN 13481. Measurement and payment per set/sleeper of delivered fastenings bridge at km 110+351,21 L=63м	set	280	4.600,00	1.288.000,00
2/2.04.03-9	**JOINING PIECES FOR JOINTS IN CHECK RAILS ON BRIDGES**. The item includes procurement and delivery to site of joining pieces for joints in 60E1 check rails. Measurement and payment per joining pieces for one joint.	pcs.	10	5.000,00	50.000,00
2/2.04.04-2	**TRACK EXPANSION JOINTS.** The item includes procurement and delivery to site of track expansion joints capacity ±100 stroke with concrete sleepers and rail fastenings. Measurement and payment per each delivered expansion joint.	pcs.	2	4.800.000,00	9.600.000,00

Item	Description	MU	Quantity	Unit price (RSD)	Total (RSD)
			A	B	AxB
2/2-04.05	**CRUSHED STONE, CATEGORY 1** The item includes procurement of crushed stone, its transport in FAD wagons to site and placing. Crushed stone grading shall comply with instruction for acceptance and delivery of crushed stone for track ballast on Serbian railways, and SRPS EN 13450. Measurement and payment per m^3 of compacted crushed stone placed in track. bridge at km 110+351,21 L=63м	m^3	403,00	4.200,00	1.692.600,00
2/2.04.06-1	**WELDING SET FOR AT WELDING OF 60E1 RAILS IN LONG RAIL LENGTHS** The item includes procurement and delivery to site of AT welding sets for rail welding. Measurement and payment per delivered AT set.	pcs.	8	6.000,00	48.000,00
				TOTAL PERMANENT WAY - PROCUREMENT OF MATERIALS:	**21.245.198,00**

2/2.05.00	**PERMANENT WAY - MATERIAL HANDLING**				
2/2.05.01	**RAIL UNLOADING.** The item includes unloading of rails from wagons and their local transport to the point of track installation. Measurement for payment per tonne of delivered rails.	t	40,36	2.700,00	108.984,00
2/2.05.02	**UNLOADING OF CONCRETE SLEEPERS FOR 60E1 RAIL WITH CHECK RAIL, 2.60m LONG.** The item includes unloading of concrete track and transition sleepers from wagon and transfer to and stacking on site. Measurement and payment per each unloaded sleeper.	pcs.	380	370,00	140.600,00
2/2.05.03	**UNLOADING OF RAIL FASTENING SYSTEM.** The item includes unloading of rail fastening system from wagons, inclusive of transport and stacking in the site warehouse. Measurement for payment per tonne of unloaded system elements.	t	4,20	2.900,00	12.180,00
2/2.05.04-1	**UNLOADING OF TRACK EXPANSION JOINTS.** The item includes unloading of track expansion joints.	pcs.	2	35.100,00	70.200,00

TOTAL PERMANENT WAY - MATERIAL HANDLING:	**331.964,00**

Item	Description	MU	Quantity	Unit price (RSD)	Total (RSD)
			A	B	AxB
2/2.06.00	**PERMANENT WAY - WORKS ON THE SUPERSTRUCTURE**				
2/2.06.04-1	**ASSEMBLY AND LAYING TRACK ON CONCRETE SLEEPERS, FIXING IT WITH ELASTIC TRACK FASTENINGS, RAIL TYPE 60E1.** The Item includes assembly and laying of track onto concrete sleepers, fixing elastic track fastenings, rail type 60E1. Measurement and payment per km of assembled and laid track. bridge at km 110+351,21 L=63м	km	0,17	6.105.000,00	1.037.850,00
2/2.06.06	**LAYING OF CHECK RAILS.** The item includes transport, handling and laying of check rails and all required rail fastenings. Payment per km of both check rails. bridge at km 110+351,21 L=63м	km	0,17	7.200.000,00	1.224.000,00
2/2.06.07	**INSTALLATION OF TRACK EXPANSION DEVICES.** The item includes installation of track expansion devices. Measurement and payment per each installation expansion devices.	pcs	2	700.000,00	1.400.000,00
2/2.06.07-1	**MECHANIZED LEVELLING AND DYNAMIC STABILIZATION OF TRACK ON CONCRETE SLEEPERS, RAIL TYPE 60E1** The item includes placing of crushed stone in track, raising of track to required reference level with cant and enlargement in curves, tamping, mechanized aligning of track on the bed and on bridges. on concrete sleepers, with elastic track fastenings, rail type 60E1, formation of ballast prism and maintenance till take-over. Measurement and payment per km of finally levelled track in designed position. bridge at km 110+351,21 L=63м	km	0,17	5.200.000,00	884.000,00
2/2.06.07-3-1	**MECHANIZED ALIGNMENT OF EXPANSION JOINTS.** The item includes placing of ballast, tamping, mechanized aligning and levelling and dynamic stabilization of expansion joints on concrete sleepers as well as ballast bed finishing and maintenance until taking over. Measurement and payment per each aligned expansion joint.	pcs	2	400.000,00	800.000,00

Item	Description	MU	Quantity	Unit price (RSD)	Total (RSD)
			A	B	AxB
2/2.06.08-1	**ELECTRIC RESISTANCE WELDING OF 60E1 RAILS TO FORM CWR** The item includes electric resistance welding of rails in 300 m long sections, finish and testing of welds, and provision of weld quality certificates for 60E1 rail type. Measurement and payment per weld. bridge at km 110+351,21 L=63м	weld	12,00	32.500,00	390.000,00
2/2.06.08-5-1	**ALUMINOTHERMIC WELDING OF EXPANSION JOINTS IN CWR.** The item includes aluminothermic welding of expansion joints in CWR, procurement of all necessary welding materials, weld treatment and test and provision of weld quality certificate. Measurement and payment per weld.	weld	8,00	36.000,00	288.000,00
2/2.06.09-1	**STRESS RELIEF IN RAILS 60E1 WITH FINAL WELDING.** The item includes stress relief in rails with final welding. Measurement for payment per km of track. bridge at km 110+351,21 L=63м	km	0,17	720.000,00	122.400,00
2/2.06.09-4	**STRESS RELIEF IN EXPANSION DEVICES AND FINAL WELDING.** The item includes stress relief in expansion devices and final welding. Measurement and payment per piece expansion joints. bridge at km 110+351,21 L=63м	pcs	2	132.000,00	264.000,00
	TOTAL PERMANENT WAY - WORKS ON THE SUPERSTRUCTURE:				**6.410.250,00**

2/2.07.00	**PERMANENT WAY - TRACKSIDE EQUIPMENT**				
2/2.07.01	**PROCUREMENT AND INSTALLATION OF POSTS.** The item includes the procurement and installation marks for control of CWR. Measurement for payment per piece of installed posts bridge at km 110+351,21 L=63м	pcs.	4,00	11.400,00	45.600,00

TOTAL PERMANENT WAY - TRACKSIDE EQUIPMENT:	**45.600,00**

Item	Description	MU	Quantity	Unit price (RSD)	Total (RSD)
			A	B	AxB

GRAND SUMMARY

2/2.04.00	**PERMANENT WAY - PROCUREMENT OF MATERIALS**	**21.245.198,00**
2/2.05.00	**PERMANENT WAY-MATERIAL HANDLING**	**331.964,00**
2/2.06.00	**PERMANENT WAY-WORKS ON THE SUPERSTRUCTURE**	**6.410.250,00**
2/2.07.00	**PERMANENT WAY-TRACKSIDE EQUIPMENT**	**45.600,00**

TOTAL (RSD): **28.033.012,00**

Responsible Designer

Dragana Jokanovic, Grad.Civ.Eng.

2/2-6.2.6.3 CALCULATIONS OF VEHICLE/ TRACK/BRIDGE INTERACTION FOR BRIDGE AT KM 110+351.21

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1.1.1.2 Results of checking the stability of the track in the horizontal plane on the bridge
1.1.1.3 Results of checking the size of the rail gap on the bridge
1.1.1.4 Technical measures to ensure safety in case of derailment of the vehicle on the bridge

1.2 Numerical documentation

1.2.1 Static calculation

1.2.1.1 Input calculation parameters of the load
1.2.1.2 Input calculation parameters of the track
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1.2.1.6 Calculation of track-bridge interaction for winter climatic conditions
1.2.1.7 Track stability in the horizontal plane on the bridge in summer climatic conditions
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1.1 Textual documentation

1.1.1 Technical report

The calculation of the track-bridge interaction for the purpose of arranging the railway superstructure on the bridge at km 110+351,21 was performed in accordance with the requirements of the Technical Specifications of Interoperability for Infrastructure Subsystem (INF TSI).

Input design load parameters are harmonized with: Technical Specifications of Interoperability for Infrastructure Subsystem, as well as Serbian standards SRPS EN 1991-1-5, SRPS EN 1991-1-5/NA, SRPS EN 1991-2, SRPS EN 1991-2/NA.

In this sense, considered the following load due to:

- relevant temperature changes in the axis of the bridge deck and continuously welded rails,
- vertical load of the vehicle in accordance with the load scheme LM 71, SW/0, SW/2.
- horizontal load due to acceleration and/or braking of the vehicle.

All input calculation data in accordance with the bridge structure, railway superstructure, as well as railway vehicles are shown in Chapters 1.2.1.1, 1.2.1.2 and 1.2.1.3. In accordance with design speed of 200 km/h, a static calculation of the track-bridge interaction was performed. The calculation was performed using an integral model of track and bridge structures, with consideration of:

- bridge parameters: bridge disposition (static system, span, expansion length), geometrical characteristics of the bridge superstructure, stiffness and arrangement of bearings,
- track parameters: rail cross-section and rail steel quality, resistance to longitudinal displacement of unloaded and loaded track, taking into account bilinear behavior,
- load parameters: temperature change in the bridge superstructure, temperature changes in the continuously welded rails, acceleration/braking of vehicles, displacement and rotation of the ends of the bridge superstructure due to traffic load.

The connection between the track and the bridge superstructure was modeled using elastic connections with bilinear behavior. The horizontal stiffness of the supporting elements is defined in the model based on UIC 774-3 recommendations and standard SRPS EN 1991-2. In this way, the influences in the rails are obtained, which are relevant for comparison with the allowed additional stresses, proving the stability of the track in the horizontal plane for maximum summer temperatures, as well as gap size due to rail cracking for maximum winter temperatures. The calculation model takes into account the track with continuously welded rails at the length of the bridge and 300 m before and after the bridge, which corresponds to the maximum influential braking length of the vehicle. The layout of the calculation model is shown in Figures 9-11. A detailed description of the model characteristics is presented in Chapter 1.2.1.4.

1.1.1.1 Results of the calculation of the track-bridge interaction

Horizontal reactions on one (of a total of two) fix bridge bearing on the abutment due to the track-bridge interaction:

Type of load	Summer climatic conditions	Winter climatic conditions
Temperature change in axis of the bridge and continuously welded rails	**-216,40 kN**	**+311,10 kN**
Acceleration + Braking the train	**±559,45 kN**	**±455,85 kN**
Vertical load from the train	**+161,25 kN**	**+180,30 kN**
Note 1: The positive direction of the reaction corresponds to the direction of growth of the chainage. Note 2: The combined effect of temperature force, acceleration + braking force and the corresponding vertical load from the train is taken to dimensioning the bridge bearings and piers.		

Maximum additional compressive and tensile stresses in continuously welded rails:

Type of load	Left track	Right track
Summer climatic conditions		
Temperature change in axis of the bridge and continuously welded rails	0,00 MPa	0,00 MPa
Acceleration /Braking	-49,18 MPa	-41,70 MPa
Vertical load from the train	0,00 MPa	0,00 MPa
Total additional compressive/tensile stresses in the relevant sections of the continuously welded rail	**-49,18 MPa ≤ -72 MPa**	**-41,70 MPa ≤ -72 MPa**
Winter climatic conditions		
Temperature change in axis of the bridge and continuously welded rails	0,00 MPa	0,00 MPa
Acceleration /Braking	+62,87 MPa	+60,30 MPa
Vertical load from the train	+12,32 MPa	+12,32 MPa
Total additional compressive/tensile stresses in the relevant sections of the continuously welded rail	**+75,19 MPa ≤ +92 MPa**	**+72,62 MPa ≤ +92 MPa**
Note 1: Pressure stresses with sign (-), tensile stresses with sign (+)		

Maximum absolute and relative displacements of the track and the bridge superstructure:

Type of displacement	Summer climatic conditions	Winter climatic conditions
Absolute horizontal displacement of the bridge superstructure due to acceleration/braking of the train	**5,00 mm ≤ 5 mm**	**4,90 mm ≤ 5 mm**
Relative horizontal displacement between the rail and the bridge superstructure due to acceleration/braking of the train	**1,28 mm ≤ 4 mm (braking)** **1,66 mm ≤ 4 mm (acceleration)**	**1,33 mm ≤ 4 mm (acceleration)** **1,53 mm ≤ 4 mm (braking)**
Horizontal displacement due to rotating of the bridge ends under the vertical load from the train	**8,30 mm ≈ 8mm**	**8,26 mm ≈ 8mm**

1.1.1.2 Results of checking the stability of the track in the horizontal plane on the bridge

Input parameters for checking the stability of the track in the horizontal plane on the bridge at extreme summer temperatures in the rails and the bridge superstructure were adopted in accordance with Chapter 1.2.1.7 and based on the results of the calculation of the track-bridge interaction.

Checking the stability of the track in the horizontal plane was carried out for the maximum value of the pressure force in the track -1574260 N, which occurs in the transition zone from the embankment to the bridge due to the built-in expansion device in the tracks on the bridge.

1.1.1.3 Results of checking the size of the rail gap on the bridge

The calculation was performed under the assumption that the maximum longitudinal resistance during elastic displacement of the rail through the system of elastic rail fastening is 30 kN/m, which corresponds to the force of longitudinal resistance 9 kN.

The calculated value of the rail gap in winter conditions is approximately 44,04 mm.

1.1.1.4 Technical measures to ensure safety in case of derailment of the vehicle on the bridge

- The guard rails, to keep trains on the track in the event of derailment, must be installed, as they can provide safety at speeds up to 160 km/h. The role of the guard rails is to keep the vehicle on track if it derailment on the bridge. In that way, the structure of the bridge is protected from damage and other negative consequences of derailment are reduced (for example. the vehicle fell off the bridge after derailment). Guard rails are mounted on sleepers with a flat upper surface. Guard rails are extended by 10 m to the embankments before and after the bridge and are connected in the middle of the track.Since V_p = 200 km/h, it is necessary to ensure that the curb upper edge of the concrete bridge deck is 25 cm above the upper edge of the sleeper.

1.2 Numerical documentation

1.2.1 Static calculation

1.2.1.1 Input calculation parameters of the load

Input calculation parameters of load are harmonized with: Technical specifications of interoperability for subsystem of infrastructure, as well as Serbian standards SRPS EN 1991-1-5, SRPS EN 1991-1-5/NA, SRPS EN 1991-2, SRPS EN 1991-2/NA.

Temperature:

- temperature change in continuously welded rails in summer climatic conditions: +42,5 K,
- temperature change in continuously welded rails in winter climatic conditions: -52,5 K,
- temperature change in the bridge superstructure in summer climatic conditions: +49 K,
- temperature change in the bridge superstructure in winter climatic conditions: -44 K.

Vertical load from the train:

- LM71

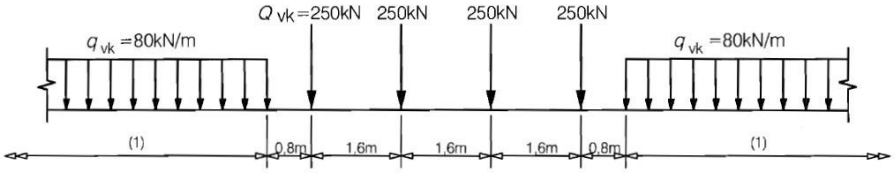
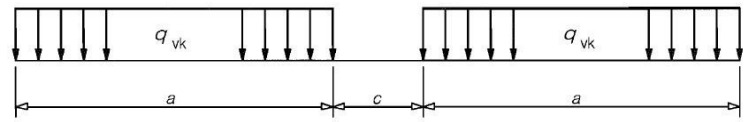


Fig. 2: Load model LM71 (α=1,21)

- SW/0, SW/2



Load Model	q_{vk} [kN/m]	a [m]	c [m]
SW/0	133	15,0	5,3
SW/2	150	25,0	7,0

Fig. 3: Load model SW/0, SW/2 (α=1,21 for SW/0)

Horizontal load from train acceleration/braking LM71, SW/0, SW/2:

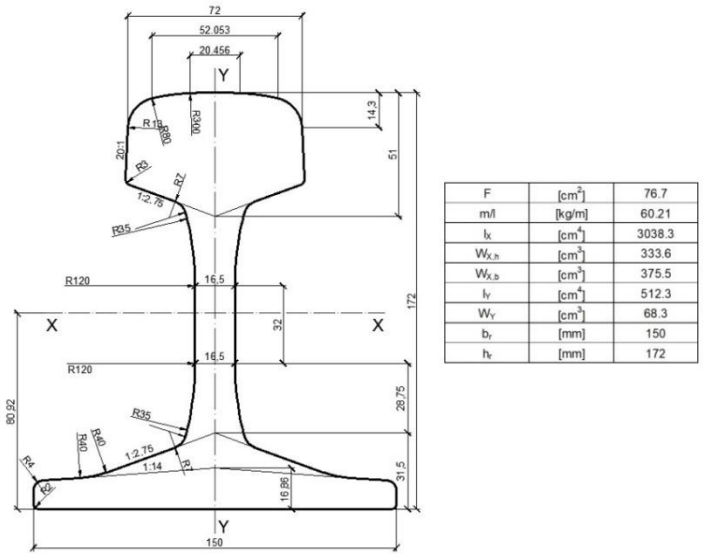
- train acceleration force 33 kN/m (≤1000 kN) for LM71, SW/0, SW/2 (α=1,21 for LM71, SW/0),
- train braking force 20 kN/m (≤6000 kN) for LM71, SW/0 (α=1,21),
- train braking force 35 kN/m for SW/2.

1.2.1.2 Input calculation parameters of the track

The input calculation parameters of the track are harmonized with: Serbian standards SRPS EN 13146-1, SRPS EN 13230 - parts 1 and 2, SRPS EN 13231, SRPS EN 13450, SRPS EN 13481 - parts 1 and 2, SRPS EN 13674-1, SRPS EN 1991-2, Law on the Safety of Railway Transport and Interoperability, as well as the Rulebook on Technical Conditions and Maintenance of the Railway Superstructure.

Rail

- rail cross-section 60E1 (tensile strength of steel 900 N/mm^2) in accordance with SRPS EN 13674-1,
- Young's modulus of elasticity of rail steel E=210 GPa,
- allowable additional tensile stress in rail foot 92 MPa in accordance with SRPS EN 1991-2,
- permissible additional pressure stress in rail 72 MPa in accordance with SRPS EN 1991-2,
- thermal expansion coefficient of rail steel α=1,15x10^{-5} 1/K.



F	[cm^2]	76.7
m/l	[kg/m]	60.21
I_X	[cm^4]	3038.3
$W_{X,h}$	[cm^3]	333.6
$W_{X,b}$	[cm^3]	375.5
I_Y	[cm^4]	512.3
W_Y	[cm^3]	68.3
b_r	[mm]	150
h_r	[mm]	172

Fig. 4: Rail cross-section 60E1 with geometric characteristics

Elastic rail fastening systems

For concrete sleepers in accordance with a series of Serbian standards SRPS EN 13481 - parts 1 and 2 and SRPS EN 13146-1.

- minimum longitudinal resistance to rail displacement ≥ 7 kN (calculated with 9 kN) in accordance with SRPS EN 13674-1,

Mono block prestressed concrete sleepers with a flat top surface

In accordance with a series of Serbian standards SRPS EN 13481-2 and SRPS EN 13230 - parts 1 and 2.

- minimum sleeper mass 281 kg without rail fastening,
- sleeper length 260 cm,
- longitudinal axial distance between sleepers 60 cm,
- minimum active backing surface of sleeper on ballast 0,57 m^2.

Rail expansion device

Rail expansion device is projected at km 110+382.55 in both tracks.

Ballast prism of gravel

In accordance with a series of Serbian standards SRPS EN 13450 with the dimensions of the ballast prism according to SRPS EN 13231.

- the minimum thickness of the ballast prism on the bridge below the lower edge of the sleeper in the cross-section below the rail 35 cm,
- width of the shoulder part of the ballast prism on the concrete deck of the bridge > 50 cm,
- resistance of the ballast prism to the longitudinal displacement of the unloaded track k=20 kN/m in accordance with SRPS EN 1991-2,
- resistance of the ballast prism to the longitudinal displacement of the loaded track k=60 kN/m in accordance with SRPS EN 1991-2.

1.2.1.3 Input calculation parameters of the bridge

The input design parameters of the bridge are defined in accordance with the characteristics of the bridge structure.

- the bridge is a simple beam static system L=63 m,
- the bridge superstructure consists of a steel truss structure with a coupled concrete deck on the lower chord of the truss,
- steel truss structure is constructed from steel grade S355,
- concrete deck is made of concrete class C35/45,
- the support of bridge superstructure on the abutments is done over 8 bearings, 4 on both abutments,
- the required minimum longitudinal (horizontal) stiffness of the supports of bridge superstructure due to acceleration/braking train is ≥ 300000 kN/m,
- the expansion length of the bridge is L_T=63 m,
- straight bridge,

- on the bridge there is a two-track railway designed for speed V_p=200 km/h,
- the maximum permissible longitudinal relative displacement between the continuously welded rail and the bridge superstructure due to acceleration/braking of the train is ≤ 4 mm,
- the maximum permissible longitudinal absolute displacement of the bridge superstructure due to acceleration/braking of the train is ≤ 5 mm,
- the maximum permissible longitudinal displacement of the bridge superstructure due to the rotation of the ends of the bridge superstructure under the vertical load from the train is ≤ 8 mm.

Longitudinal section

Fig. 5: Longitudinal section of the bridge on km 110+351,21

Cross-section

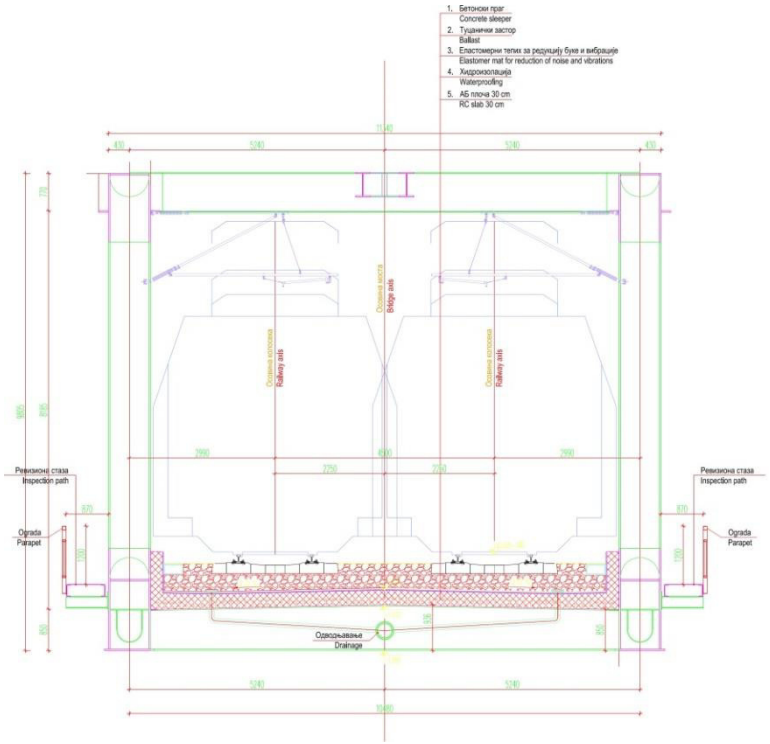


Fig. 6: Cross-section of the bridge on km 110+351,21

Bearing scheme

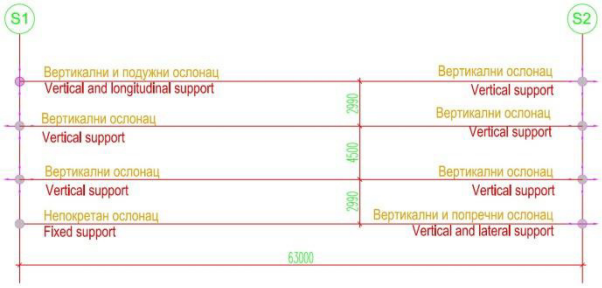
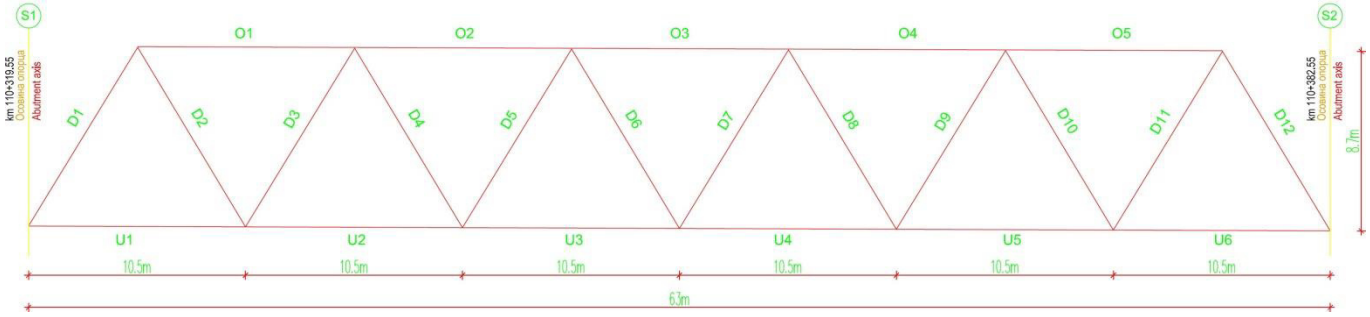


Fig. 7: Bearing scheme of bridge on km 110+351,21

Geometrical characteristics of elements bridge superstructure

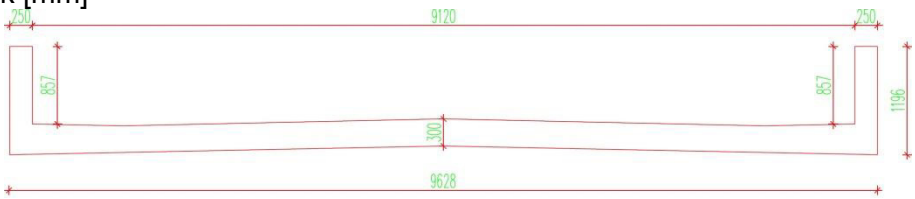
Steel truss structure with coupling concrete deck:



- Elements of steel truss structure [mm]

ГЛАВНИ НОСАЧ / MAIN GIRDER				
Доњи појас / Bottom cord	ЕЛЕМЕНТ / ELEMENT	ЕЛЕМЕНТ ПОПРЕЧНИ ПРЕСЕК / ELEMENT CROSS-SECTION U1, U2, U5, U6	ЕЛЕМЕНТ ПОПРЕЧНИ ПРЕСЕК / ELEMENT CROSS-SECTION U3, U4	МАТЕРИЈАЛ / MATERIAL
	ГОРЊА ФЛАНША b1xt1 / TOP FLANGE b1xt1	800x20	800x25	t≤20mm: S355 J2+Z15 20<t≤35mm: S355 J2+Z25 t>35mm: S355 K2+Z25
	ДОЊА ФЛАНША b2xt2 / BOTTOM FLANGE b2xt2	1100x15	1100x20	
	РЕБРА hwxtw / WEBS hwxtw	1430x15	1430x20	
	ПОДУЖНА УКРУЋЕЊА РЕБАРА / WEBS LONGITUDINAL STIFFENERS	250x20	250x20	
Горњи појас / Top cord	ЕЛЕМЕНТ / ELEMENT	ЕЛЕМЕНТ ПОПРЕЧНИ ПРЕСЕК / ELEMENT CROSS-SECTION O1, O5	ЕЛЕМЕНТ ПОПРЕЧНИ ПРЕСЕК / ELEMENT CROSS-SECTION O2, O3, O4	
	ГОРЊА ФЛАНША b1xt1 / TOP FLANGE b1xt1	800x30	800x40	
	ДОЊА ФЛАНША b2xt2 / BOTTOM FLANGE b2xt2	250x30	250x40	
	РЕБРА hwxtw / WEBS hwxtw	730x25	730x25	
Дијагонале / Diagonals	ЕЛЕМЕНТ / ELEMENT	ЕЛЕМЕНТ ПОПРЕЧНИ ПРЕСЕК / ELEMENT CROSS-SECTION		
		D1, D12	D2, D11	D3, D10	D4, D9	D5 - D8
	ФЛАНША bfxtf / FLANGE bfxtf	750x40	700x30	650x25	550x20	550x15
	РЕБРА hwxtw / WEBS hwxtw	800x30	800x15	800x15	800x15	800x10

- Concrete deck [mm]



Material characteristics of the elements bridge superstructure

All elements of the steel truss structure are made of steel grade S355 with the following characteristics:

Steel grade S355:

- $E=2,1x10^{8}$ kN/m^2
- v=0,3
- $\alpha=1,2x10^{-5}$ 1/C
- $\rho=76,98$ kN/m^3

Concrete deck is made of concrete class C35/45 with the following characteristics:

Concrete class C35/45:

- $E= 3,4077x10^{7}$ kN/m^2 ($Er=9,33x10^{6}$ kN/m^2 - reduced value of cracked concrete with reinforcement)
- v=0,2
- $\alpha=1,0x10^{-5}$ 1/C
- $\rho=25,00$ kN/m^3

Steel reinforcement in the concrete is grade B500B:

Steel reinforcement grade B500B:

- $E=2,1x10^{8}$ kN/m^2
- v=0,3
- $\alpha=1,2x10^{-5}$ 1/C
- $\rho=78,00$ kN/m^3

1.2.1.4 Calculation model of track-bridge interaction

Based on the calculation of the track-bridge interaction, the influences are obtained in the following form:

- longitudinal forces in supports (reactions of fixed supports),
- additional stresses in rails,
- absolute and relative displacements of the rails and the bridge superstructure.

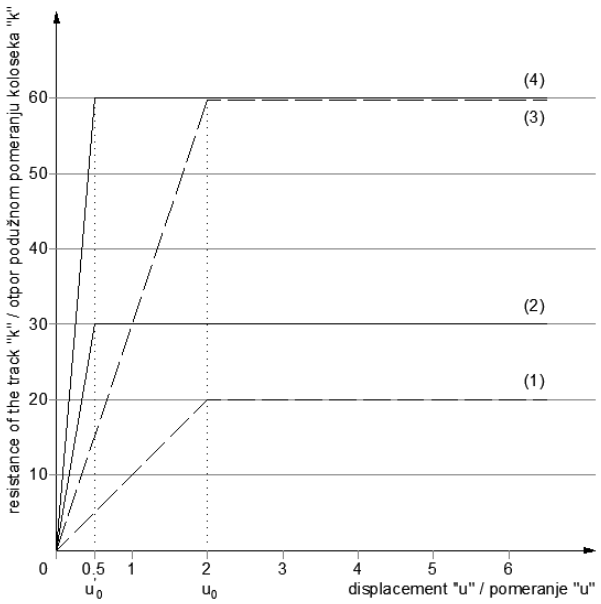
Influences due to interaction are determined iteratively, by a series of nonlinear simulations, in order to determine the behavior of the track-bridge system, due to temperature changes in the bridge superstructure, vertical load from the train and longitudinal forces due to train acceleration/braking.

The calculation of the track-bridge interaction is carried out using an integral model of track and bridge structure taking into account:

- bridge parameters: bridge disposition (static system, spans, expansion lengths), geometrical characteristics of the bridge superstructure, stiffness of structure and arrangement of supports,
- track parameters: rail cross-section and rail steel quality, resistance to longitudinal displacement of loaded and unloaded track, taking into account the bilinear behavior of the track-bridge connection,
- load parameters: temperature changes in the bridge superstructure and rails, acceleration and braking of the train, displacement and rotating the ends of the bridge super structure due to traffic load.

The connection between the track elements and the bridge superstructure elements was modeled by means of elastic connections with bilinear behavior in accordance with the Serbian standard SRPS EN 1991-2 (Figure 8).

The model adopts the horizontal stiffness of the fixed support, which corresponds to the real displacement of the bridge superstructure due to acceleration/braking the train. In this way, the influences in the rails are obtained, which are relevant for the analysis of the allowed additional stresses and track stability in the horizontal plane at maximum summer temperature, as well as the size of the gap when the rail cracks at maximum winter temperature. The calculation model takes into account the track with continuously welded rails at a length of 300 m in before and after the bridge, which corresponds to the maximum influential length of train braking.



(1) - resistance of sleeper in ballast (unloaded track)
otpor podužnom pomeranju praga kroz zastor (neopterećen kolosek)

(2) - resistance of rail in sleeper (unloaded track) (frozen ballast or track without ballast)
otpor podužnom pomeranju šine u odnosu na prag (neopterećen kolosek) (smrznuti zastor ili kolosek na čvrstoj podlozi)

(3) - resistance of sleeper in ballast (loaded track)
otpor podužnom pomeranju praga kroz zastor (opterećen kolosek)

(4) - resistance of rail in sleeper (loaded track) (frozen ballast or track without ballast)
otpor podužnom pomeranju šine u odnosu na prag (opterećen kolosek) (smrznuti zastor ili kolosek na čvrstoj podlozi)

u'_0 - ultimate relative displacement of the rail to the sleeper
granično relativno pomeranje šine u odnosu na prag

u_0 - ultimative relative displacement of the sleeper in the ballast
granično relativno pomeranje praga u odnosu na zastor

Note: / Napomena:
rail profile 60E1, concrete sleepers B70 at a distance of 60 cm and longitudinal resistance of the rail in the track 2x9 kN, minimum thickness of the compacted ballast below the sleeper is 30 cm.
šine 60E1, betonski pragovi B70 na razmaku 60 cm i podužni otpor šina u koloseku 2x9 kN, minimalna debljina zbijenog zastora ispod praga 30 cm.

Fig. 8: Longitudinal displacement resistance of track/rail

View of calculation model

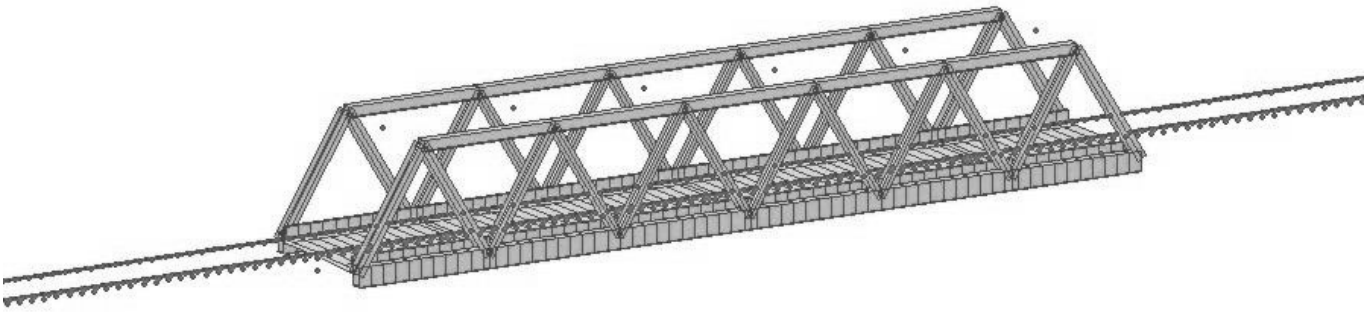


Fig. 9: View of calculation model

Longitudinal section of the calculation model

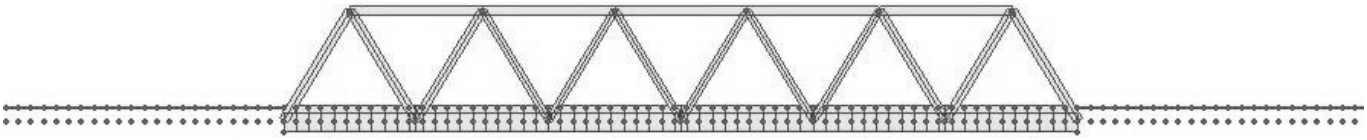


Fig. 10: Longitudinal section of the calculation model

Cross-section of calculation model

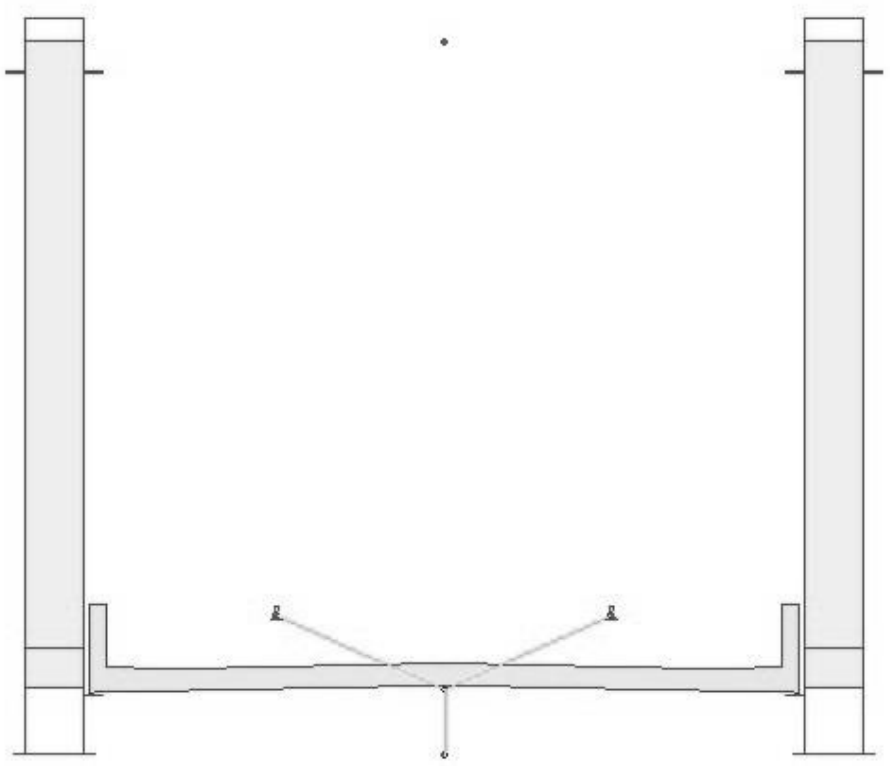
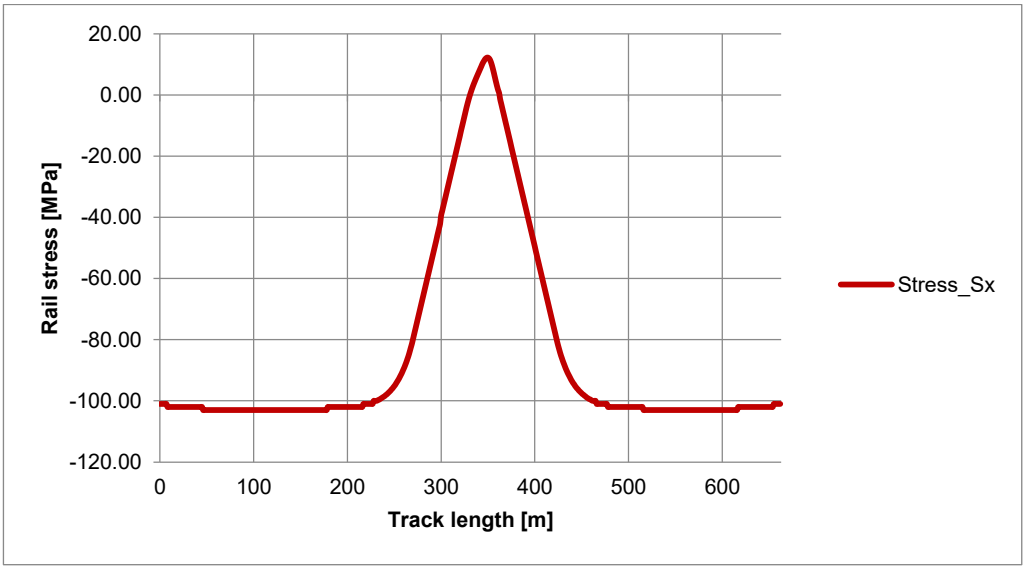


Fig. 11: Cross-section of the calculation model with elastic connections with bilinear behavior between the track and the bridge superstructure

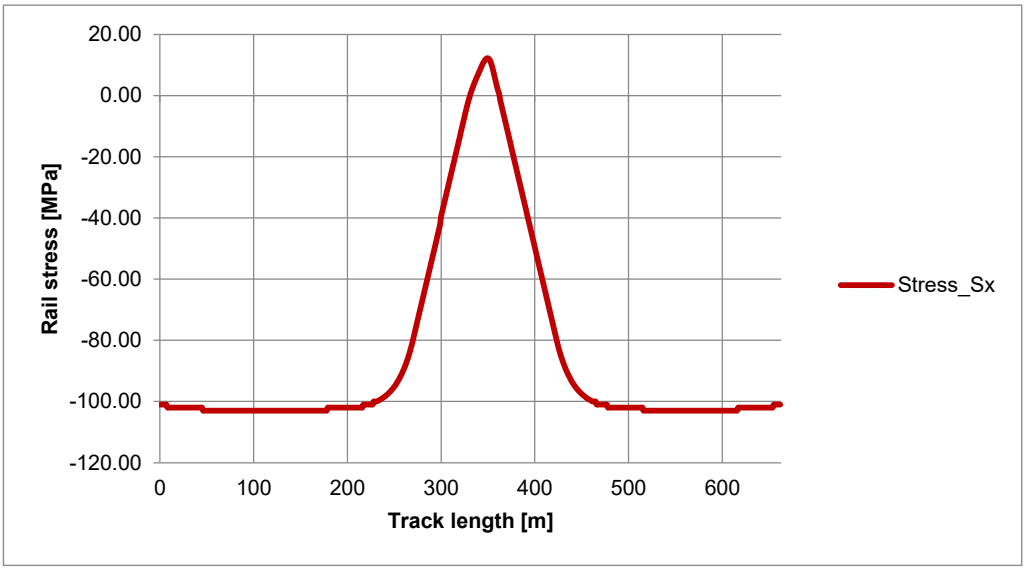
1.2.1.5 Calculation of track-bridge interaction for summer climatic conditions

1) Rail stress due to temperature change in bridge superstructure and continuously welded rails
Left track



Maximum pressure stress in rail = **-42,10 MPa (the additional pressure stress is equal to zero)**
Maximum tensile stress in rail = **0,00 MPa**

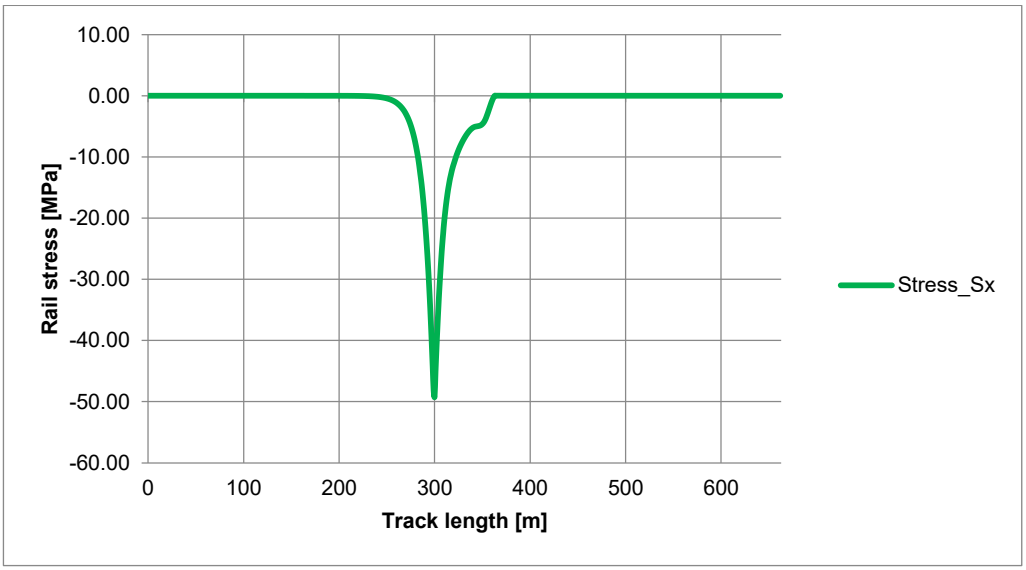
Right track



Maximum pressure stress in rail = **-42,10 MPa (the additional pressure stress is equal to zero)**
Maximum tensile stress in rail = **0,00 MPa**

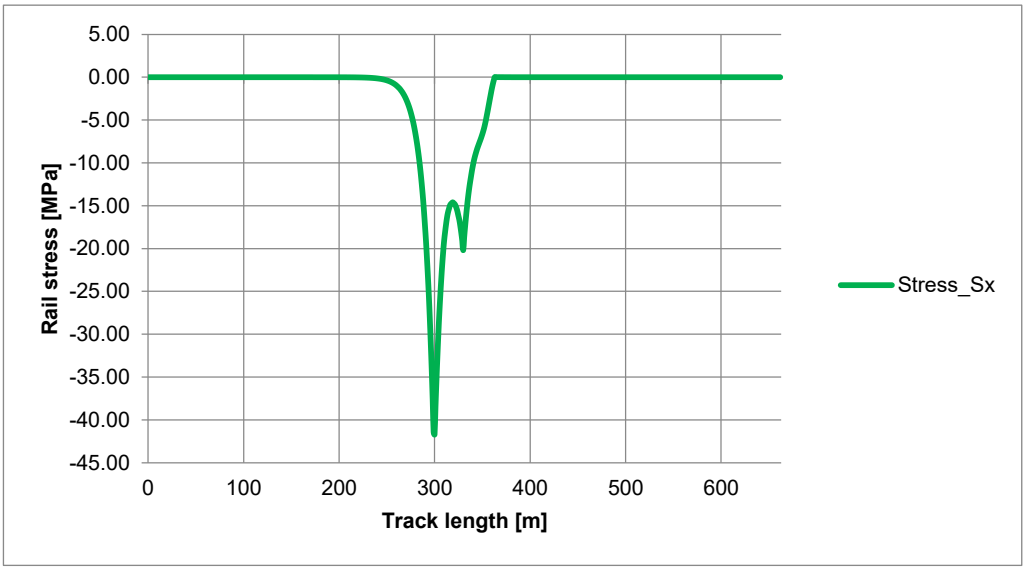
2) Rail stress due to train acceleration/braking

Left track (train braking)



Maximum pressure stress in rail = **-49,18 MPa**
Maximum tensile stress in rail = **0,00 MPa**

Right track (train acceleration)

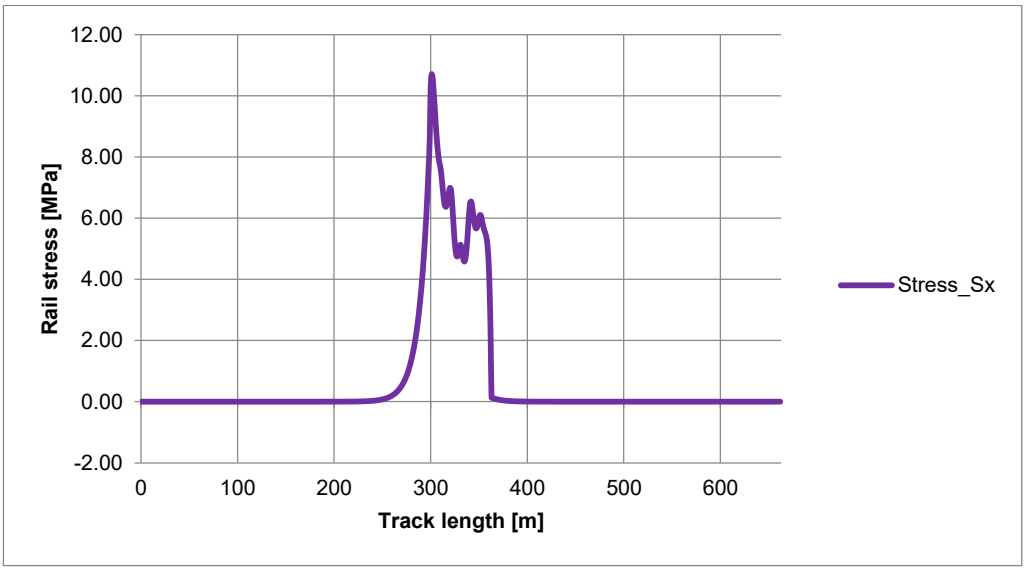


Maximum pressure stress in rail = **-41,70 MPa**

Maximum tensile stress in rail = **0,00 MPa**

3) Rail stress due to vertical bending under train

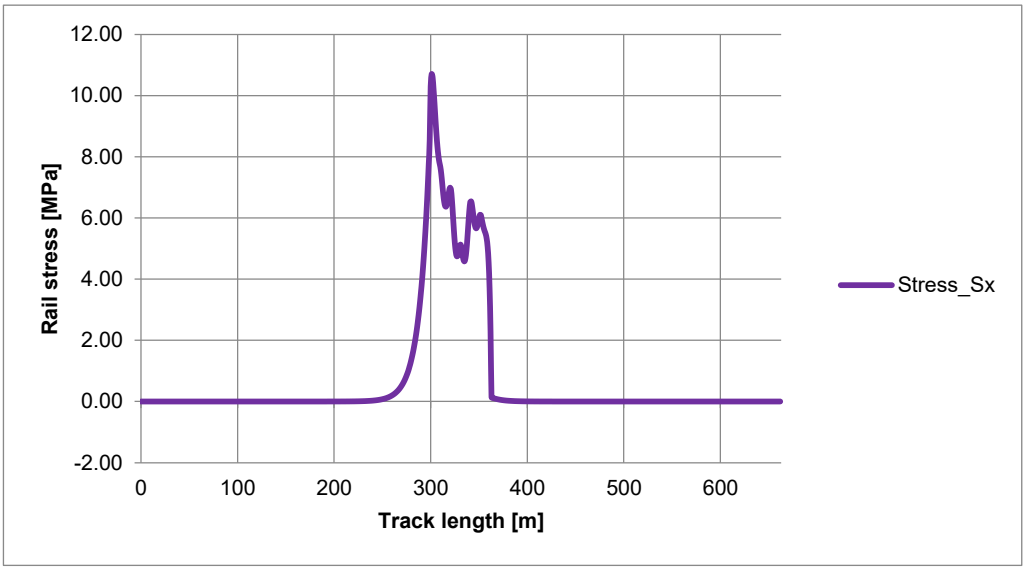
Left track



Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+10,66 MPa**

Right track



Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+10,66 MPa**

4) Rail stress due to temperature change in bridge superstructure, train acceleration/braking and vertical bending under train

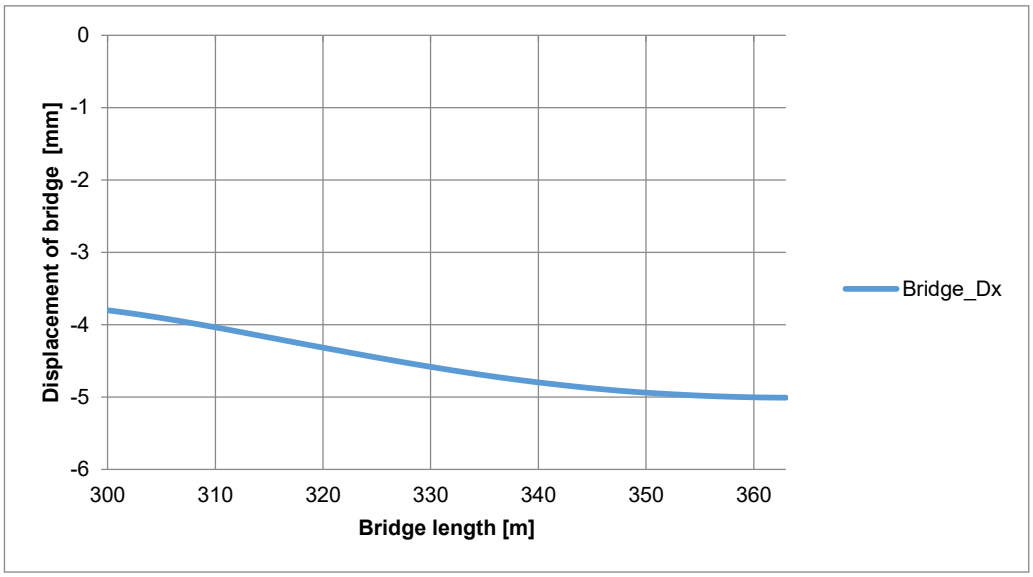
Left track

Maximum pressure stress in rail = **-0,00-49,18-0,00 = -49,18 MPa ≤ -72,00 MPa**

Right track

Maximum pressure stress in rail = **-0,00-41,70-0,00 = -41,70 MPa ≤ -72,00 MPa**

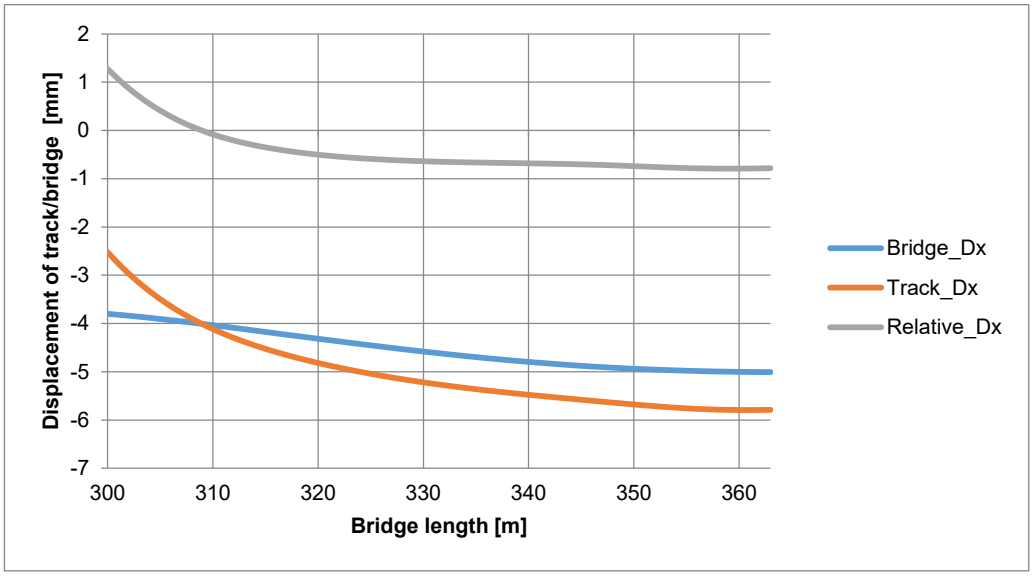
5) Absolute horizontal displacement of bridge superstructure due to acceleration/braking of the train



Maximum absolute horizontal displacement of bridge superstructure due to acceleration/braking of the train = **5,00 mm ≤ 5 mm**

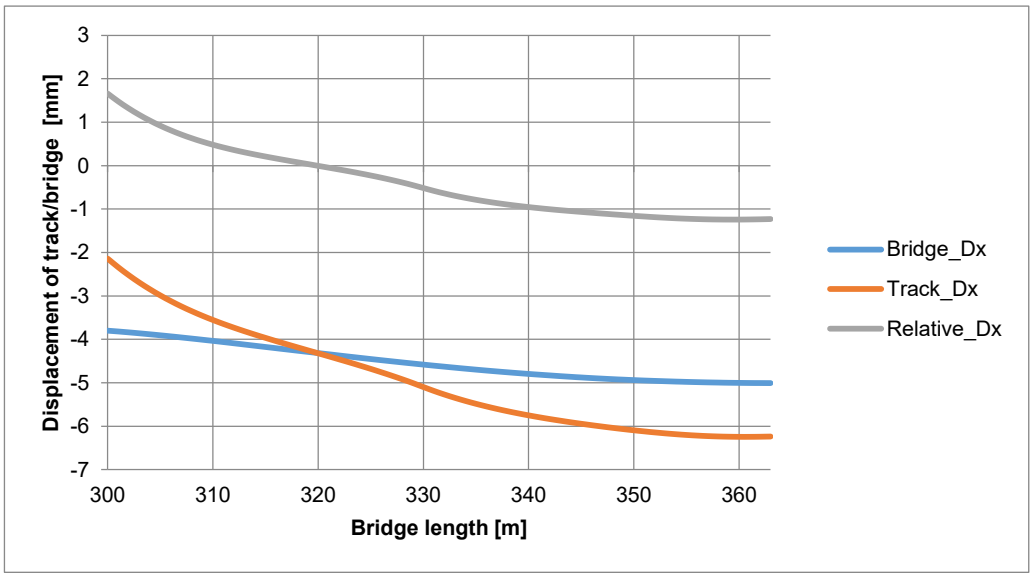
6) Relative horizontal displacement between rail and bridge superstructure due to acceleration/braking of the train

Left track (train braking)



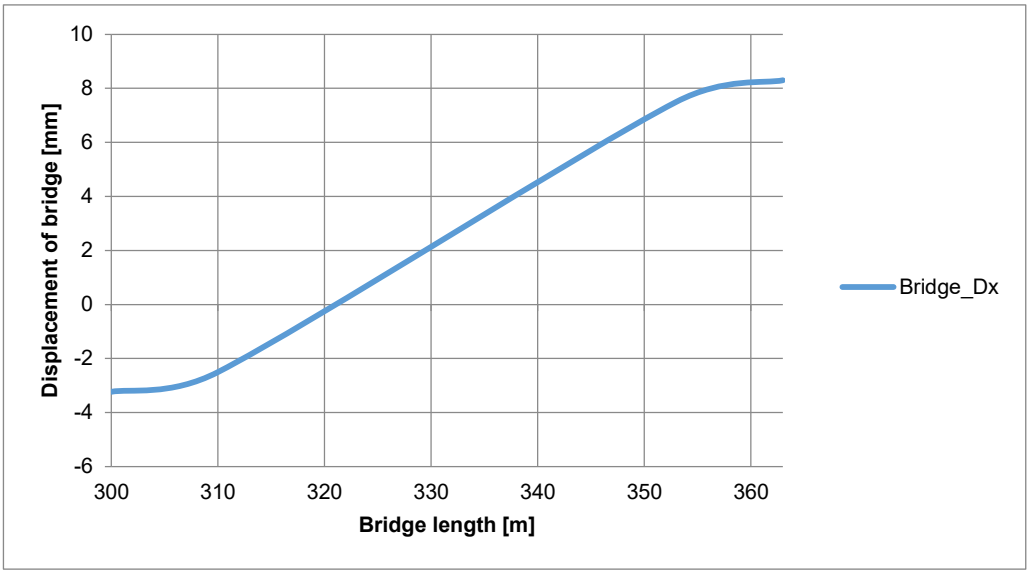
Maximum relative horizontal displacement between rail and bridge superstructure due to braking of the train = **1,28 mm ≤ 4 mm**

Right track (train acceleration)



Maximum relative horizontal displacement between rail and bridge superstructure due to acceleration of the train = **1,66 mm ≤ 4 mm**

7) Horizontal displacement due to rotating of the bridge ends under the vertical load from the train

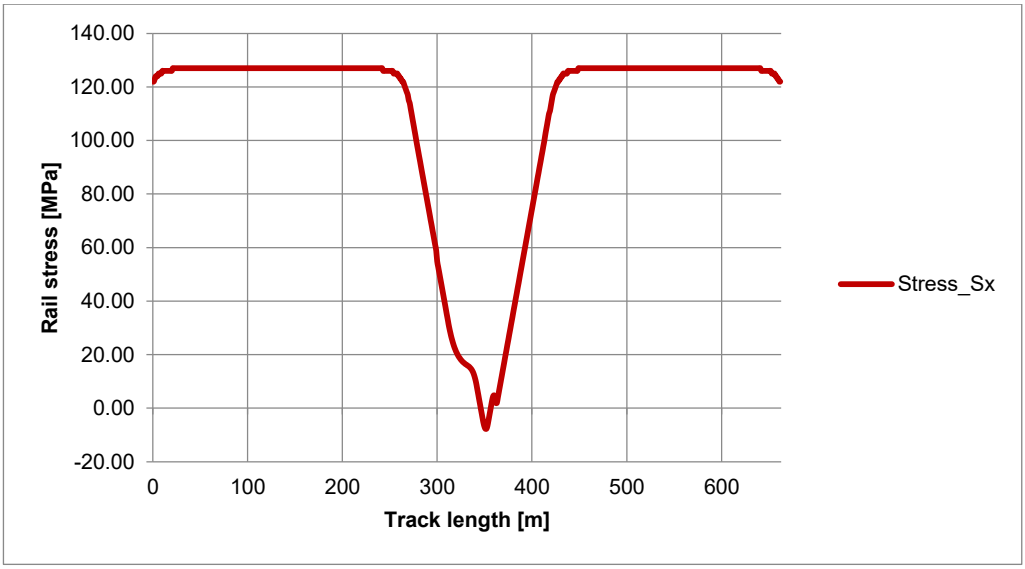


Maximum horizontal displacement due to rotating of the bridge ends under the vertical load from the train = **8,30 mm ≈ 8 mm**

1.2.1.6 Calculation of track-bridge interaction for winter climatic conditions

1) Rail stress due to temperature change in bridge superstructure and continuously welded rails

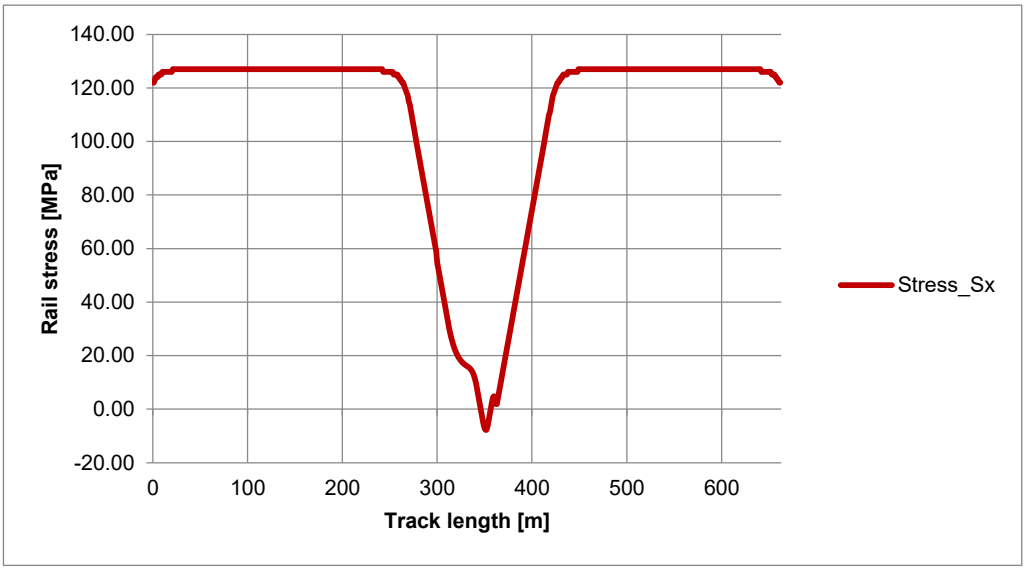
Left track



Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+58,80 MPa (the additional tensile stress is equal to zero)**

Right track

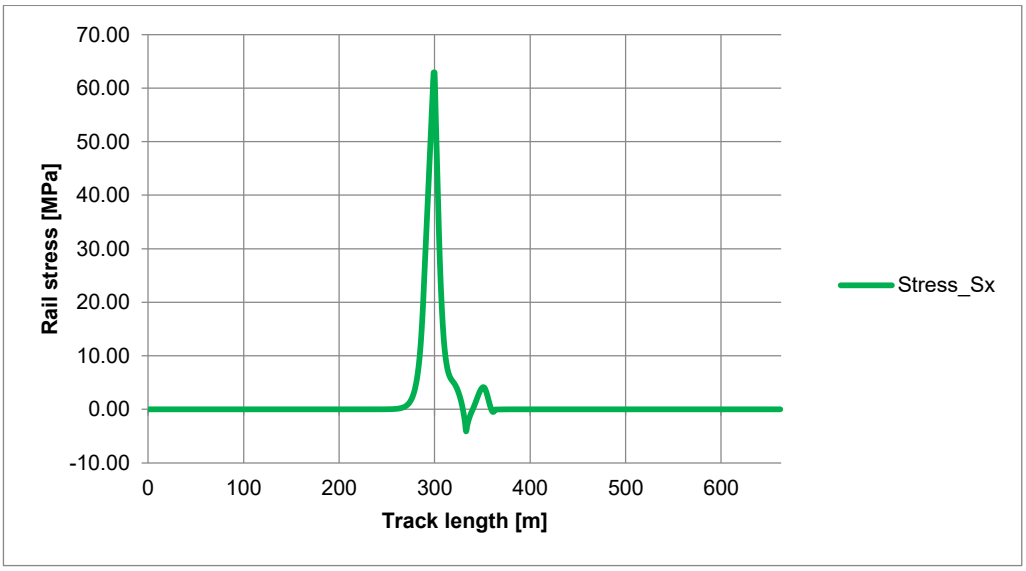


Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+58,80 MPa (the additional tensile stress is equal to zero)**

2) Rail stress due to train acceleration/braking

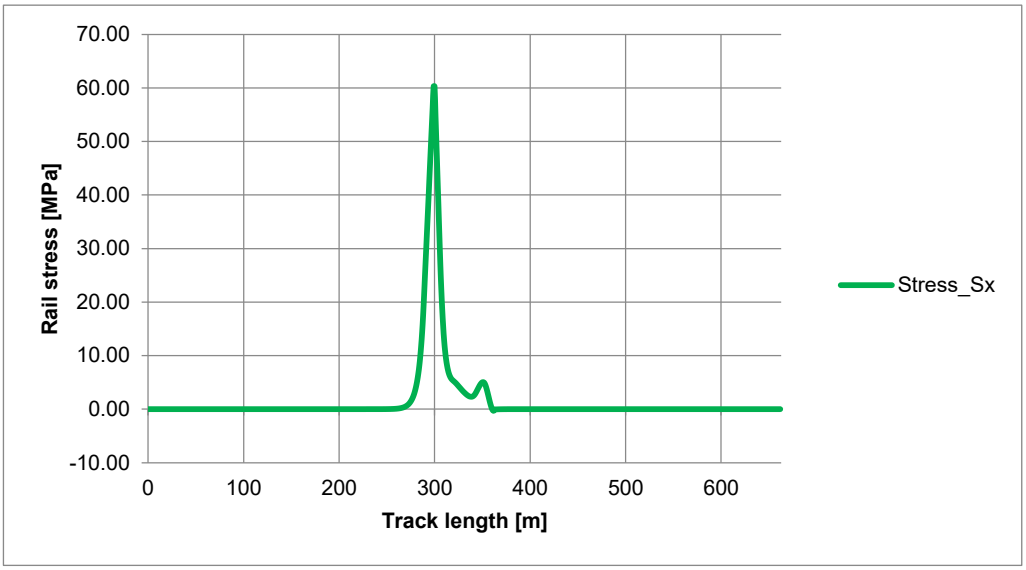
Left track (train acceleration)



Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+62,87 MPa**

Right track (train braking)

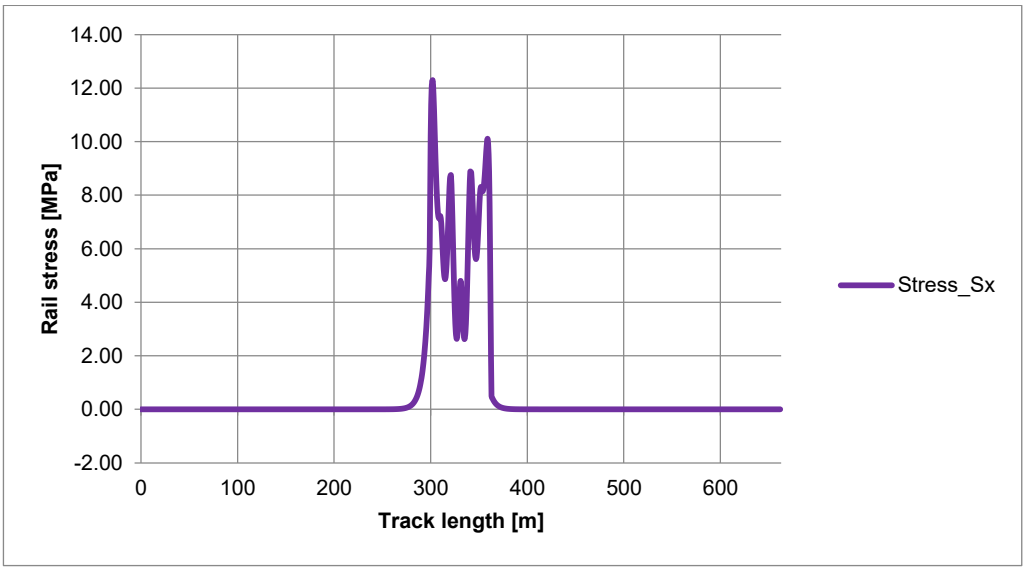


Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+60,30 MPa**

3) Rail stress due to vertical bending under train

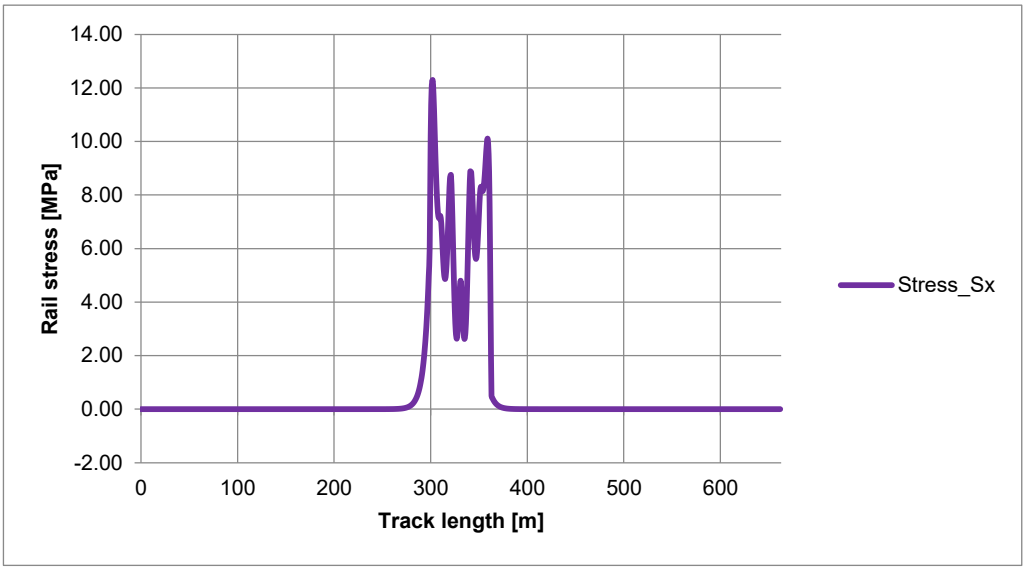
Left track



Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+12,32 MPa**

Right track



Maximum pressure stress in rail = **0,00 MPa**

Maximum tensile stress in rail = **+12,32 MPa**

4) Rail stress due to temperature change in bridge superstructure, train acceleration/braking and vertical bending under train

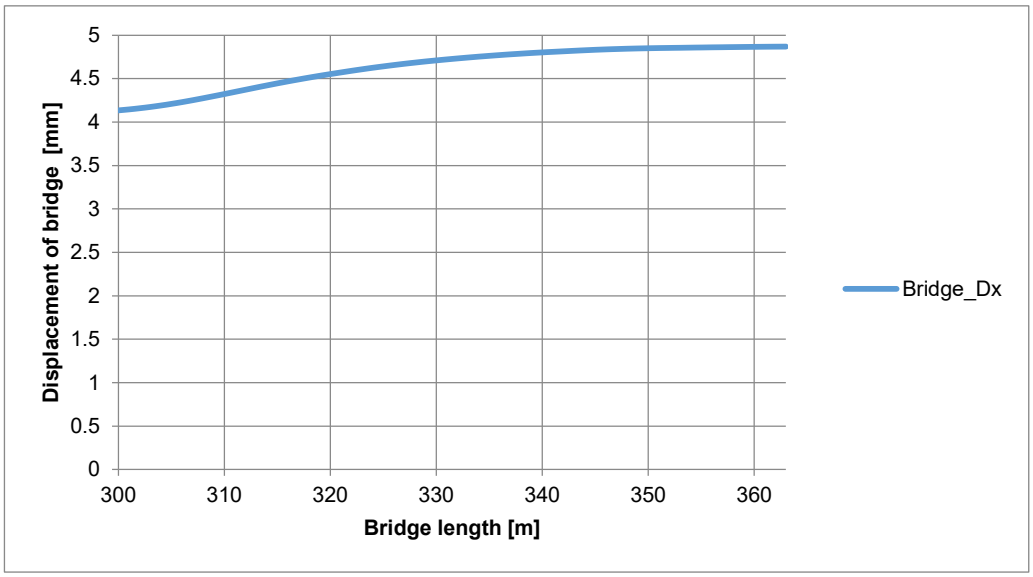
Left track

Maximum tensile stress in rail = **+0,00+62,87+12,32 = +75,19 MPa ≤ +92,00 MPa**

Right track

Maximum tensile stress in rail **= +0,00+60,30+12,32 = +72,62 MPa ≤ +92,00 MPa**

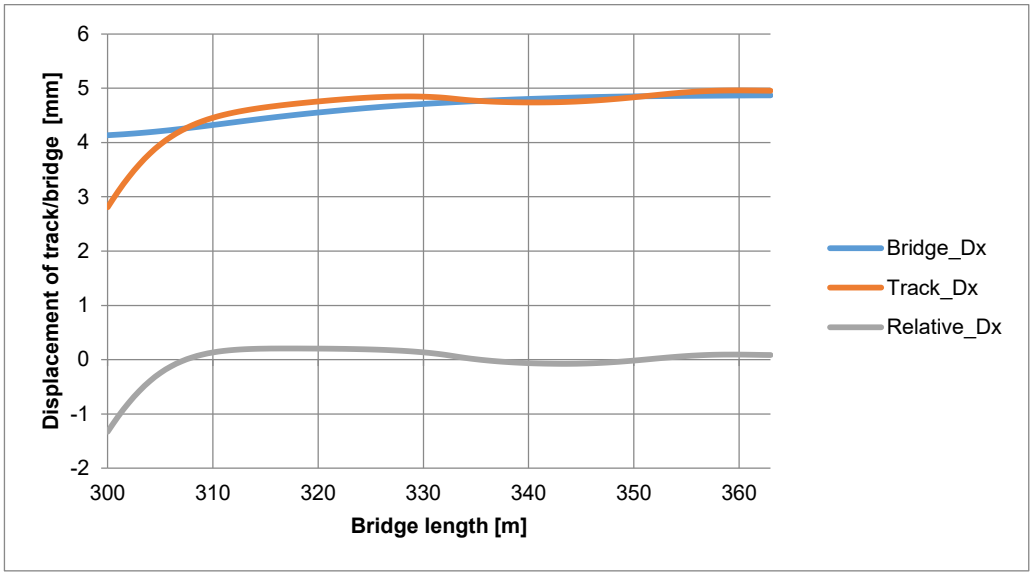
5) Absolute horizontal displacement of bridge superstructure due to acceleration/braking of the train



Maximum absolute horizontal displacement of bridge superstructure due to acceleration/braking of the train = **4,90 mm ≤ 5 mm**

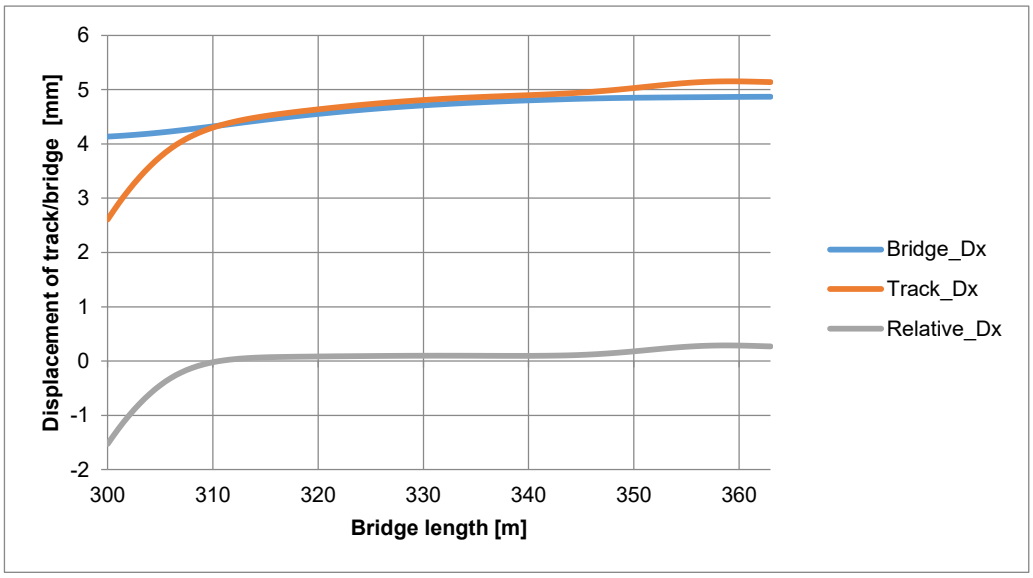
6) Relative horizontal displacement between rail and bridge superstructure due to acceleration/braking of the train

Left track (train acceleration)



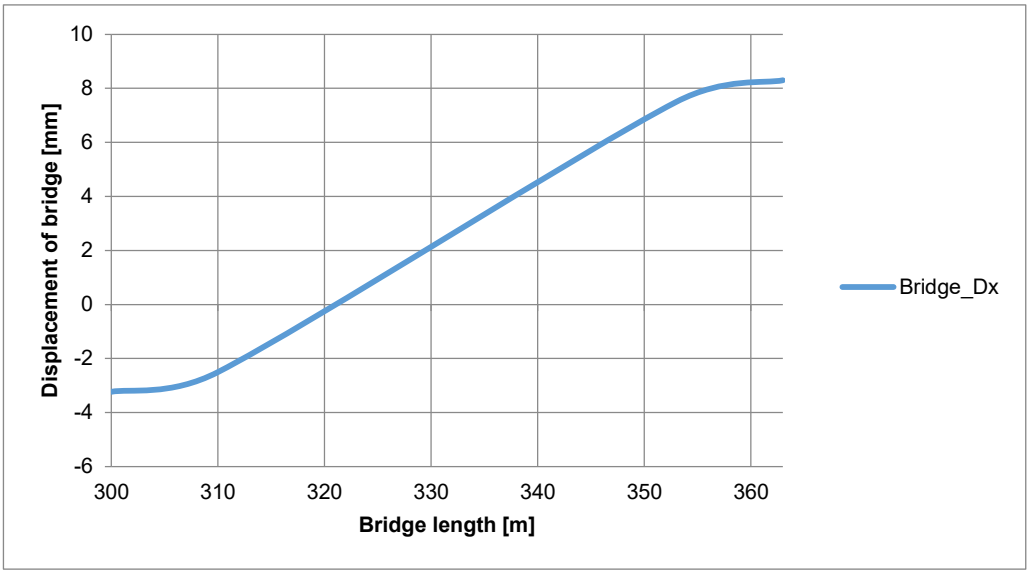
Maximum relative horizontal displacement between rail and bridge superstructure due to acceleration of the train **= 1,33 mm ≤ 4 mm**

Right track (train braking)



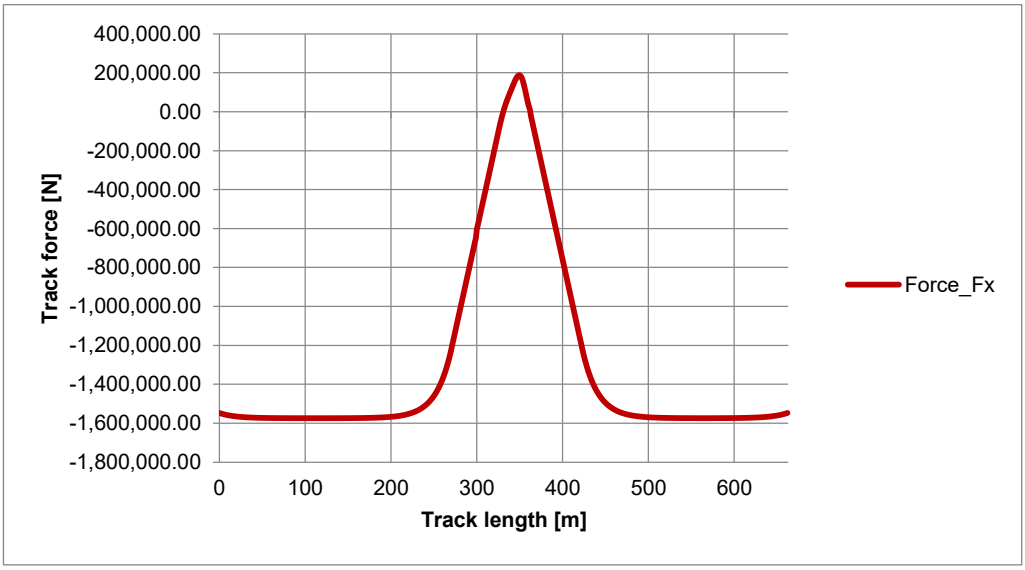
Maximum relative horizontal displacement between rail and bridge superstructure due to braking of the train = **1,53 mm ≤ 4 mm**

7) Horizontal displacement due to rotating of the bridge ends under the vertical load from the train



Maximum horizontal displacement due to rotating of the bridge ends under the vertical load from the train = **8,26 mm ≈ 8 mm**

1.2.1.7 Track stability in the horizontal plane on the bridge in summer climatic conditions

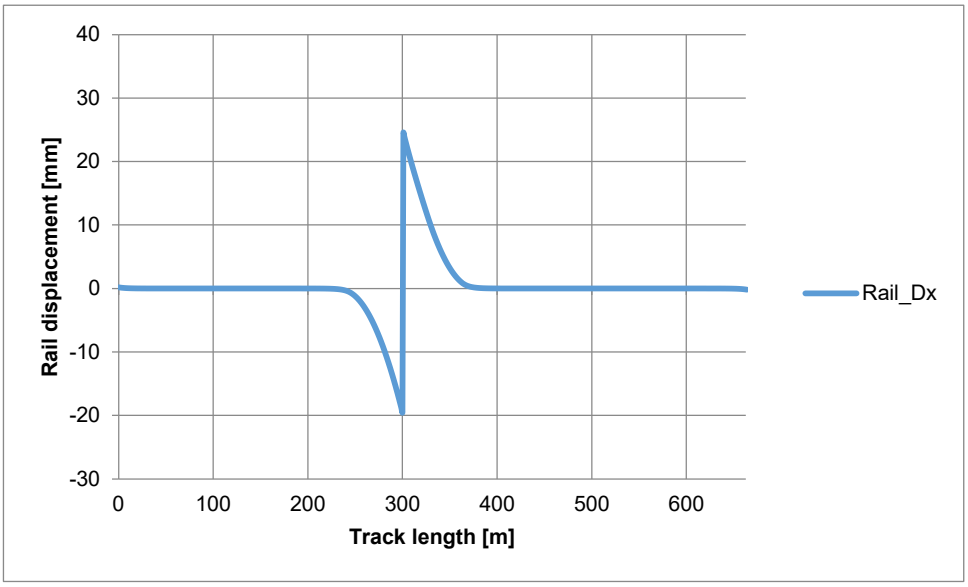


Maximum temperature pressure force in track on the bridge in summer climatic conditions relevant for the calculation of track stability in the horizontal plane = -1574260 N

The input parameters for the calculation of the track stability in the horizontal plane on the bridge in extreme summer climatic conditions are in accordance with Chapters 1.2.1.1, 1.2.1.2 and 1.2.1.3 as well as calculation results of the track/bridge interaction.

Checking the stability of the track in the horizontal plane was carried out for the maximum value of the pressure force in the track -1574260 N, which occurs in the transition zone from the embankment to the bridge due to the built-in rail expansion device in the track on the bridge.

1.2.1.8 Size of the rail gap on the bridge in winter climatic conditions

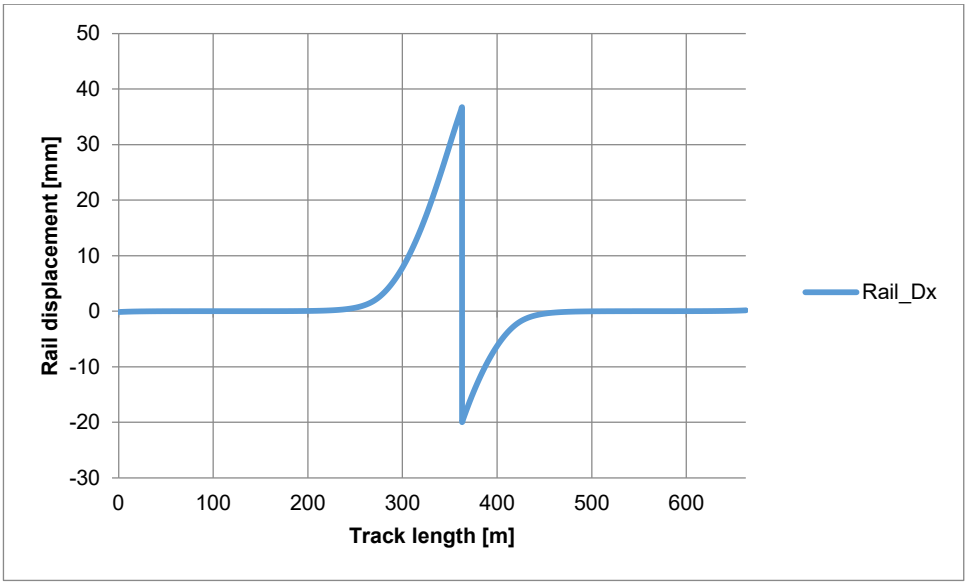


Maximum size of the gap due to cracking of the rail on the bridge in winter climatic conditions in the = **44,04 mm.**

1.2.1.9 Capacity of the rail expansion device in the track on the bridge

The rail expansion device in the track is designed at km 110+382,55 in both tracks.

Summer climatic conditions



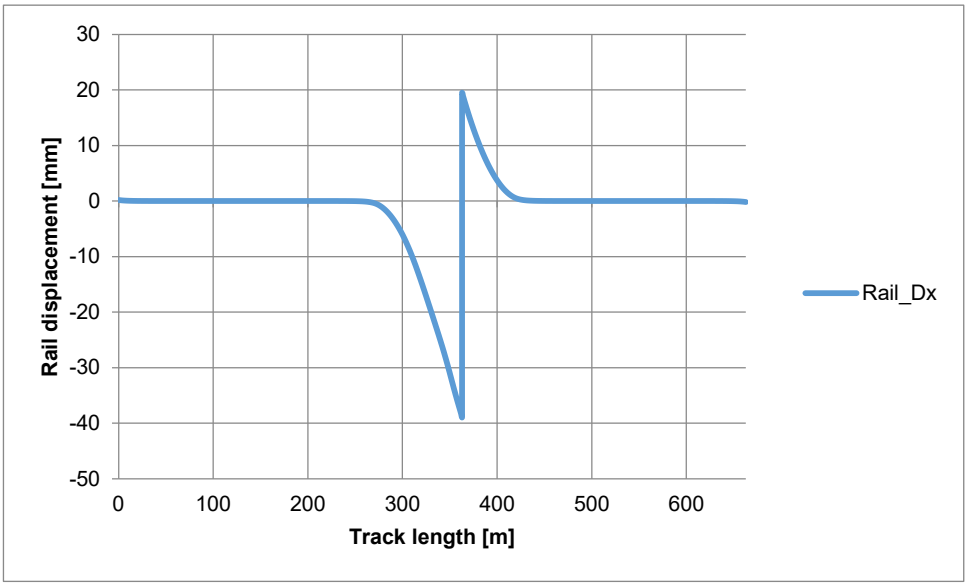
The maximum rail elongation on the bridge in summer climatic conditions **= +36,74 mm**

The maximum rail elongation on the bridge due to braking/acceleration **= +6,24 mm**

The maximum rail elongation on the bridge due to train vertical load **= +8,30 mm**

The total maximum rail elongation on the bridge = 1,5 x (+36,74 + 6,24 + 8,30) **= +76,92 mm**

Winter climatic conditions



The maximum rail contraction on the bridge in winter climatic conditions **= -38,91 mm**

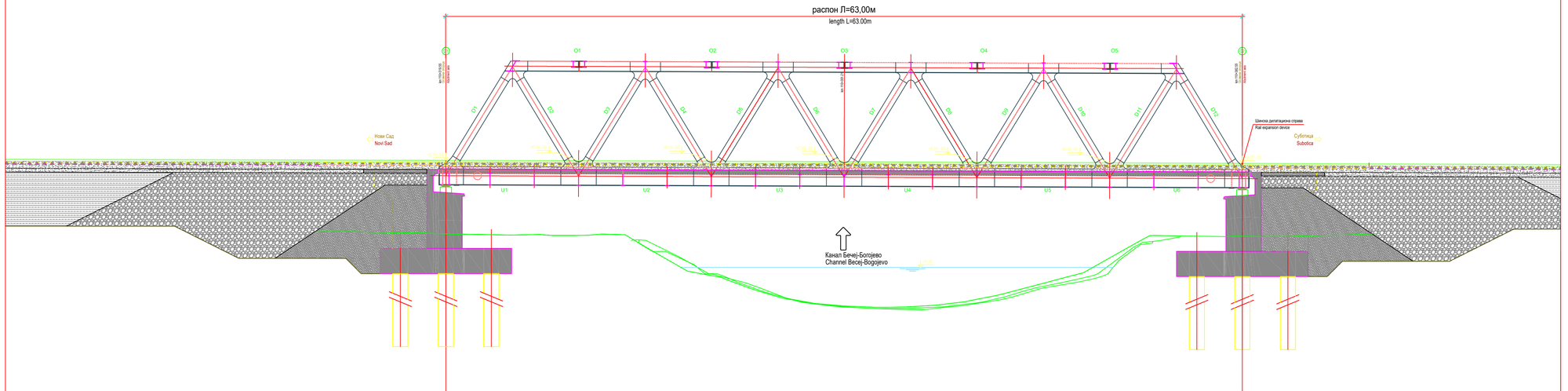
The maximum rail contraction on the bridge due to braking/acceleration **= -5,14 mm**

The total maximum rail contraction on the bridge = 1,5 x (-38,91 - 5,14) **= -66,08 mm**

The installation of rail expansion devices in both tracks with a minimum capacity of **a = ±100 mm** at km 110+382.55 is required. (The capacity of the rail expansion device in the track is harmonized with the calculation of the bridge structure dilatation within the static calculation of the bridge.)

Calculated by:
Zoran Lukovic,dipl.gradj.inz.
licenca broj 310 3032 03

2/2-6.2.7.
GRAPHIC DOCUMENTATION



Број /Number	Датум / Date	Опис / Description
03		
02		
01		

Ревизиони блок: / Revision block:

САОБРАЋАЈНИ ИНСТИТУТ ЦИП, д.о.о.
INSTITUTE OF TRANSPORTATION CIP ltd
Немањина 6; 11000 Београд; Србија
Тел: 011/3618-134; Факс: 011/3618-324; web site: www.sicip.co.rs

Организациона јединица:САОБРАЋАЈНИЦЕ /Organization unit:DEPARTMENT OF ROADS AND RAILWAYS

Responsible designer:
Драгана Јокановић, дипл.инж.грађ.
лиценца број: / license No.: 315 1404 03

Сарадници: / Associates:

Инвеститор пројекта:
" ИНФРАСТРУКТУРА ЖЕЛЕЗНИЦЕ СРБИЈЕ " А.Д.
/ " INFRASTRUCTURE RAILWAYS OF SERBIA " JSC
Немањина 6/IV, Београд / Nemanjina Street 6/IV, Belgrade

Наручилац пројекта:
Joint Venture of
China Railway International Corporation Ltd. (CRIC)
No.10 Fuxing Road,Haidian District,Beijing
P.R China, 100844

China Communication Construction Company Ltd. (CCCC)
No.85 Deshengmenwai Street,Xicheng District,Beijing
P.R China, 100088

Објекат: /Structure:
ПРУГА БЕОГРАД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)
ДЕОНИЦА ПРУГЕ НОВИ САД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)

BELGRADE - SUBOTICA - STATE BORDER (KELEBIA) RAILWAY LINE
SECTION : NOVI SAD - SUBOTICA - STATE BORDER (KELEBIA)

Део пројекта: / Part of Design:
2/2.6.2 ПРОЈЕКАТ ГОРЊЕГ СТРОЈА ЗА МОСТОВСКЕ КОНСТРУКЦИЈЕ ДУЖИНЕ ПРЕКО 40М-ДЕОНИЦА РУМЕНКА ИЗЛАЗ-ВРБАС НОВА ПУТНИЧКА УЛАЗ
2/2.6.2 DESIGN OF SUPERSTRUCTURE FOR BRIDGE STRUCTURES LONGER THAN 40M SECTION RUMENKA EXIT-VRBAS NOVA PASSENGER ENTRY

Унутрашња контрола: / Intermal control:
Милан Јелкић, дипл. грађ. инж.

Главни пројектант: /Chief designer:
Др Љиљана Милић Марковић, дипл.грађ.инж.

Руководилац организационе јединице:
Manager of organization unit:
мр Новица Стевановић , дипл.инж.грађ.

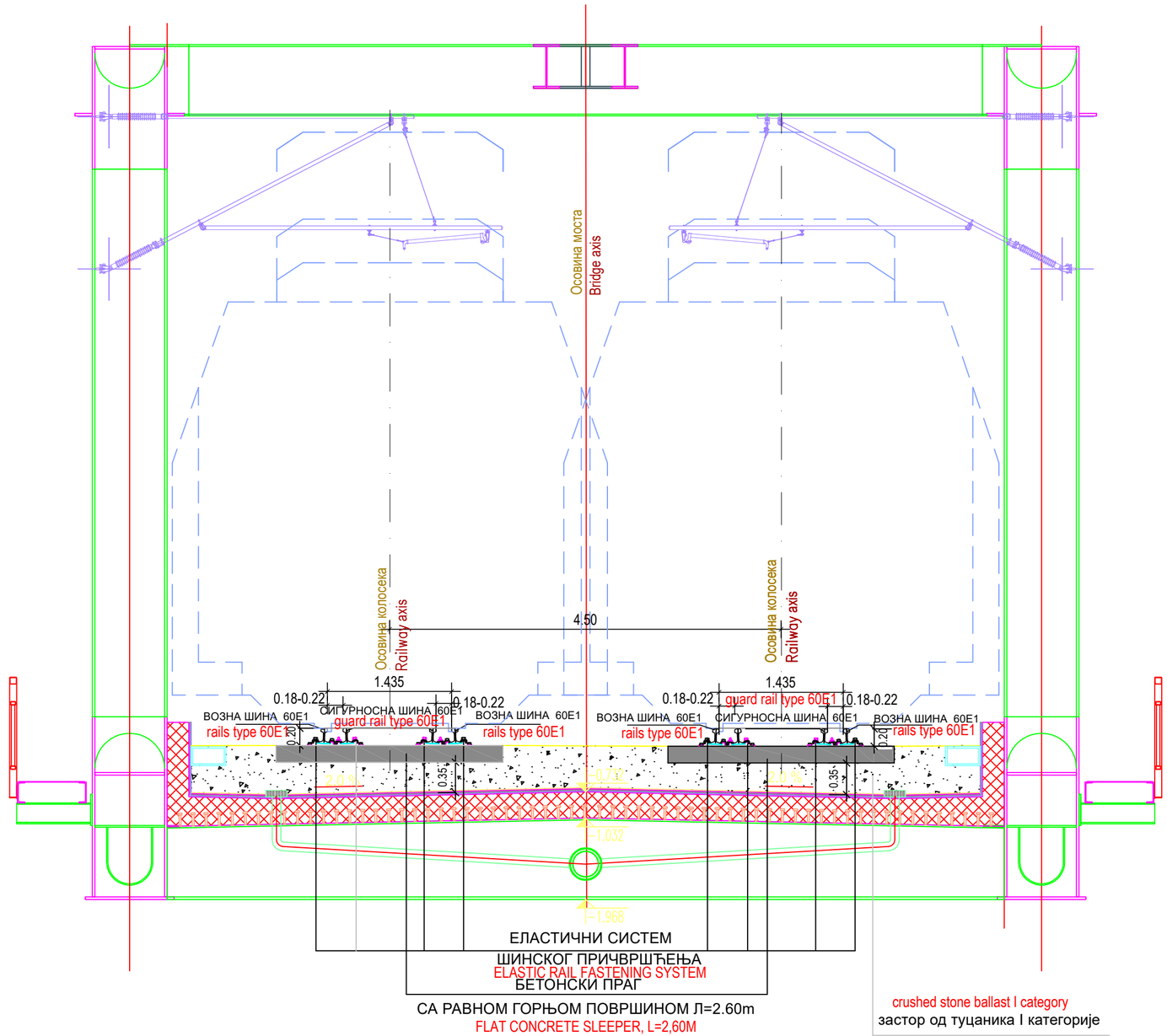
Цртеж: / Drawing: **ПОДУЖНИ ПРЕСЕК МОСТА НА КМ 110+351.21 Д.К.**
LONGITUDINAL PROFILE OF THE BRIDGE AT KM 110+351.21 R.T.

Размера: Scale: 1:200

Врста тех.док.: Type of tech.docum.: **ПЗИ** / DFC

датум/date: **08.2021**

Цртеж бр. /Drawing No.: 2020-250-CAO-2/2-6.2.7.1.



Број /Number	Датум / Date	Опис / Description
03		
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01		

Ревизиони блок: / Revision block:

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INSTITUTE OF TRANSPORTATION CIP ltd
Немањина 6; 11000 Београд; Србија
Тел: 011/3618-134; Факс: 011/3618-324; web site: www.sicip.co.rs

Организациона јединица:САОБРАЋАЈНИЦЕ /Organization unit:DEPARTMENT OF ROADS AND RAILWAYS

Responsible designer:
Драгана Јокановић, дипл.инж.грађ.
лиценца број: / license No.: 315 1404 03

Сарадници: / Associates:

Унутрашња контрола: / Interrnal control:

Главни пројектант: /Chief designer:
Др ЉиљанаМилић Марковић, дипл.грађ.инж.

Руководилац организационе јединице:
Manager of organization unit:
мр Новица Стевановић , дипл.инж.грађ.

Инвеститор пројекта:
" ИНФРАСТРУКТУРА ЖЕЛЕЗНИЦЕ СРБИЈЕ " А.Д.
/ " INFRASTRUCTURE RAILWAYS OF SERBIA " JSC
Немањина 6/IV, Београд / Nemanjina Street 6/IV, Belgrade

Наручилац пројекта: Joint Venture of
China Railway International Corporation Ltd. (CRIC)
No.10 Fuxing Road,Haidian District,Beijing
P.R China, 100844
China Communication Construction Company Ltd. (CCCC)
No.85 Deshengmenwai Street,Xicheng District,Beijing
P.R China, 100088

Објекат: /Structure:
ПРУГА БЕОГРАД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)
ДЕОНИЦА ПРУГЕ НОВИ САД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)

BELGRADE - SUBOTICA - STATE BORDER (KELEBIA) RAILWAY LINE
SECTION : NOVI SAD - SUBOTICA - STATE BORDER (KELEBIA)

Део пројекта: / Part of Design:
2/2.6.2 ПРОЈЕКАТ ГОРЊЕГ СТРОЈА ЗА МОСТОВСКЕ КОНСТРУКЦИЈЕ ДУЖИНЕ ПРЕКО 40М-ДЕОНИЦА РУМЕНКА ИЗЛАЗ-ВРБАС НОВА ПУТНИЧКА УЛАЗ
2/2.6.2 DESIGN OF SUPERSTRUCTURE FOR BRIDGE STRUCTURES LONGER THAN 40M SECTION RUMENKA EXIT-VRBAS NOVA PASSENGER ENTRY

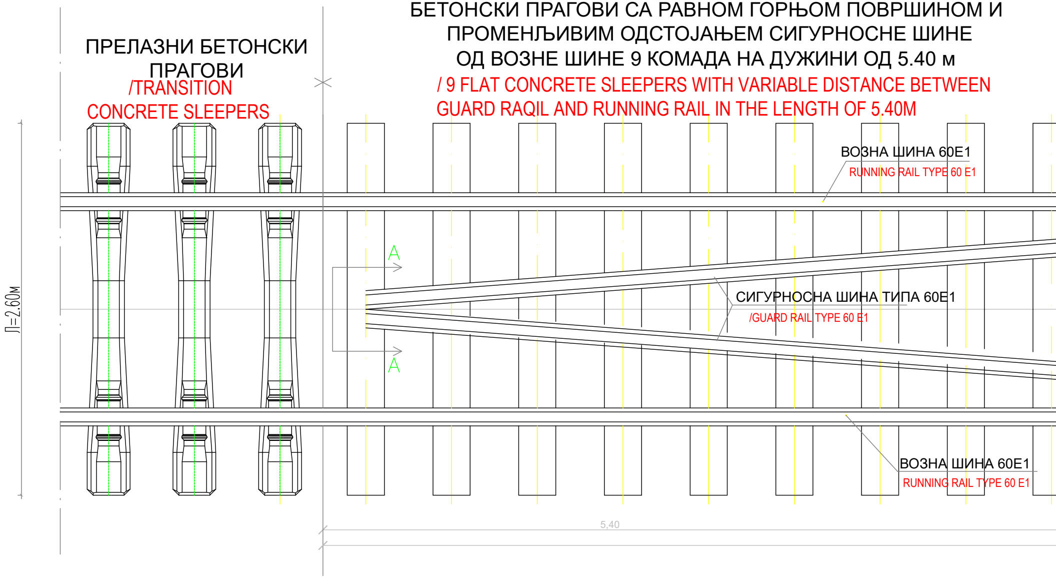
Цртеж: / Drawing:
ПОПРЕЧНИ ПРОФИЛ МОСТА НА КМ 110+351,21
CROSS SECTION OF THE BRIDGE AT KM 110+351.21 R.T.

Размера: Scale: 1:50

Врста тех.док.: Type of tech.docum.	датум:/date	Цртеж бр. /Drawing No.:
ПЗИ / DFC	08.2021	2020-250-CAO-2/2-6.2.7.2

БЕТОНСКИ ПРАГОВИ СА ЕЛАСТИЧНОМ П

/CONCRETE SLEEPERS WITH ELASTIC RAIL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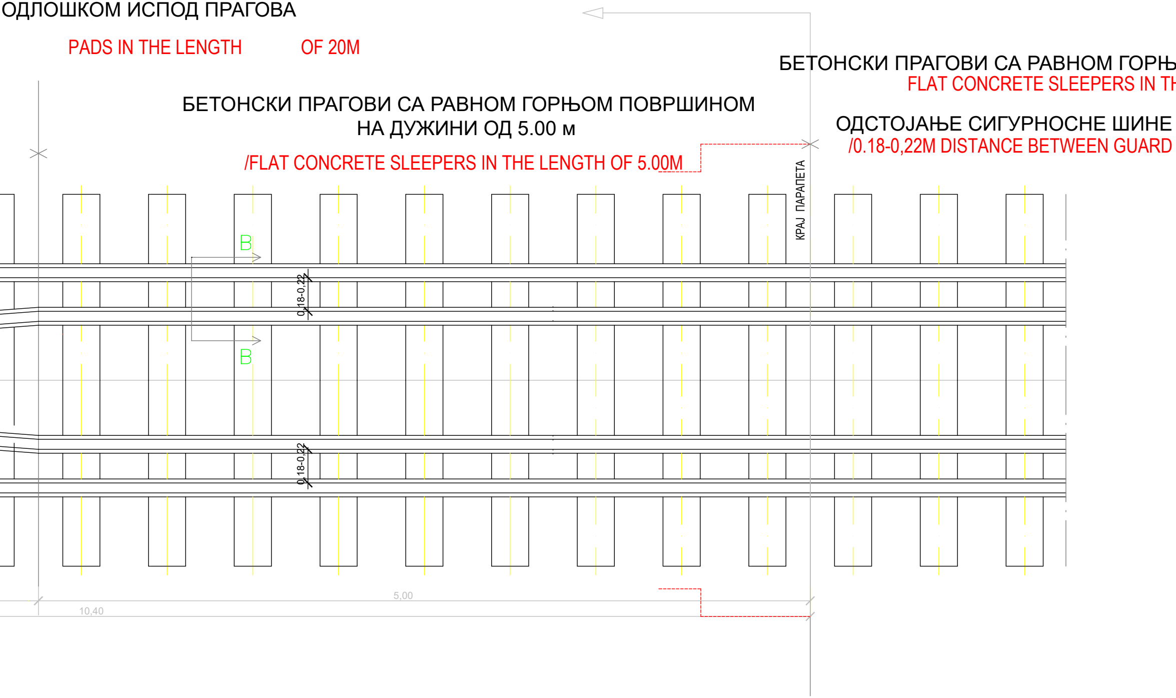
/ 9 FLAT CONCRETE SLEEPERS WITH VARIABLE DISTANCE BETWEEN GUARD RAQIL AND RUNNING RAIL IN THE LENGTH OF 5.40M
ПРЕЛАЗНИ БЕТОНСКИ ПРАГОВИ
/TRANSITION CONCRETE SLEEPERS
ВОЗНА ШИНА 60Е1
RUNNING RAIL TYPE 60 E1
A
A
СИГУРНОСНА ШИНА ТИПА 60Е1
/GUARD RAIL TYPE 60 E1
ВОЗНА ШИНА 60Е1
RUNNING RAIL TYPE 60 E1
Л=2.60м
5,40

ДИСПОЗИЦИЈА КОЛОСЕКА НА МОСТ
ТИП ШИН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PADS IN THE LENGTH
OF 20M
БЕТОНСКИ ПРАГОВИ СА РАВНОМ ГОРЊОМ ПОВРШИНОМ
НА ДУЖИНИ ОД 5.00 м
/FLAT CONCRETE SLEEPERS IN THE LENGTH OF 5.00M
БЕТОНСКИ ПРАГОВИ СА РАВНОМ ГОРЊ
FLAT CONCRETE SLEEPERS IN TH
ОДСТОЈАЊЕ СИГУРНОСНЕ ШИНЕ
/0.18-0,22M DISTANCE BETWEEN GUARD
КРАЈ ПАРАПЕТА
B
B
0,18-0,22
0,18-0,22
5,00
10,40

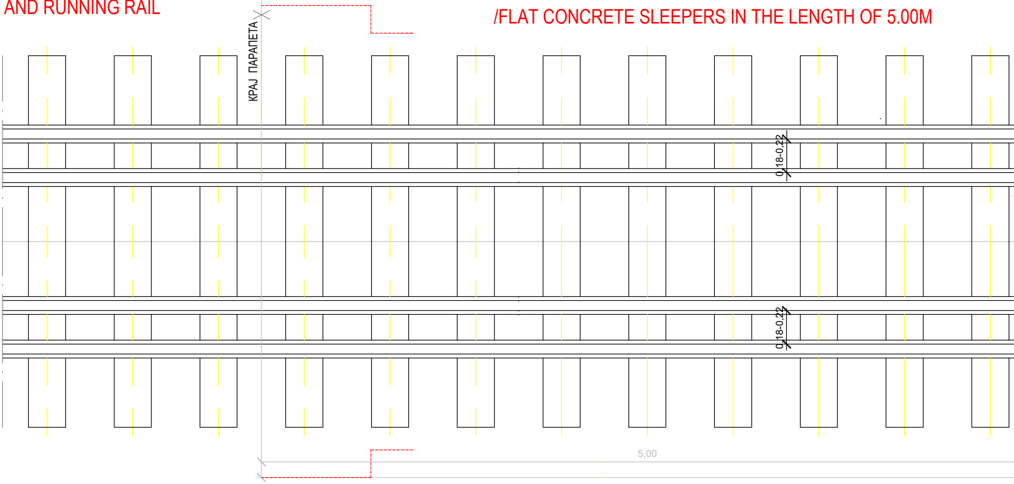
ОВИМА СА СИГУРНОСНОМ ШИНОМ /LAYOUT OF TRACKS WITH GUARD RA
E 60E1/RAILS TYPE 60E1

БЕТОНСКИ ПРАГОВИ СА ЕЛАСТИЧНО

ОМ ПОВРШИНОМ У ЗОНИ МОСТА
HE BRIDGE AREA

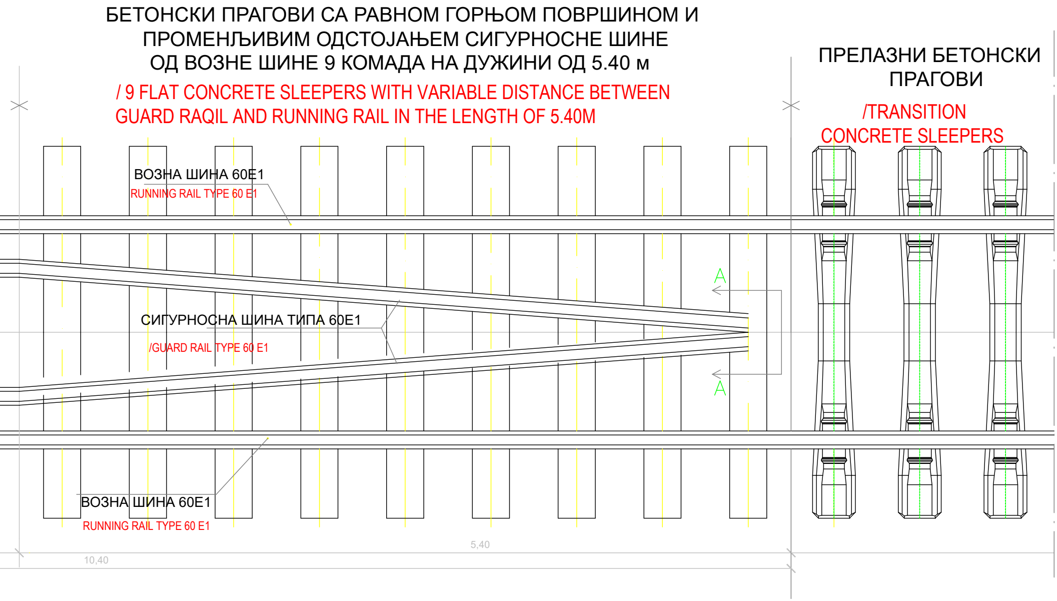
ОД ВОЗНЕ ШИНЕ 0.18-0,22 м
RAIL AND RUNNING RAIL

БЕТОНСКИ ПРАГОВИ СА РАВНОМ ГОРЊОМ ПОВРШИНОМ
НА ДУЖИНИ ОД 5.00 м
/FLAT CONCRETE SLEEPERS IN THE LENGTH OF 5.00M


КРАЈ ПАРАПЕТА
0,18-0,22
0,18-0,22
5,00

ILS ON BRIDGE

М ПОДЛОШКОМ ИСПОД ПРАГОВА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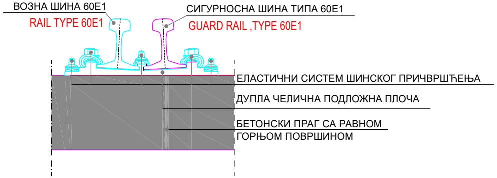
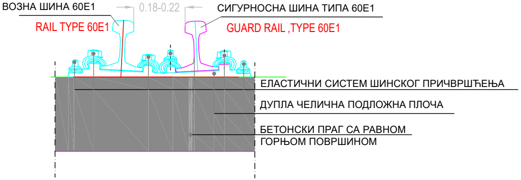
/ 9 FLAT CONCRETE SLEEPERS WITH VARIABLE DISTANCE BETWEEN GUARD RAQIL AND RUNNING RAIL IN THE LENGTH OF 5.40M
ПРЕЛАЗНИ БЕТОНСКИ ПРАГОВИ
/TRANSITION CONCRETE SLEEPERS
ВОЗНА ШИНА 60Е1
RUNNING RAIL TYPE 60 E1
СИГУРНОСНА ШИНА ТИПА 60Е1
/GUARD RAIL TYPE 60 E1
A
A
ВОЗНА ШИНА 60Е1
RUNNING RAIL TYPE 60 E1
5,40
10,40

A-A
P=1:10


ВОЗНА ШИНА 60Е1
RAIL TYPE 60E1
СИГУРНОСНА ШИНА ТИПА 60Е1
GUARD RAIL ,TYPE 60E1
ЕЛАСТИЧНИ СИСТЕМ ШИНСКОГ ПРИЧВРШЋЕЊА
ДУПЛА ЧЕЛИЧНА ПОДЛОЖНА ПЛОЧА
БЕТОНСКИ ПРАГ СА РАВНОМ
ГОРЊОМ ПОВРШИНОМ

B-B
P=1:10


ВОЗНА ШИНА 60Е1
RAIL TYPE 60E1
0.18-0.22
СИГУРНОСНА ШИНА ТИПА 60Е1
GUARD RAIL ,TYPE 60E1
ЕЛАСТИЧНИ СИСТЕМ ШИНСКОГ ПРИЧВРШЋЕЊА
ДУПЛА ЧЕЛИЧНА ПОДЛОЖНА ПЛОЧА
БЕТОНСКИ ПРАГ СА РАВНОМ
ГОРЊОМ ПОВРШИНОМ

03		
02		
01		
Број/Number	Датум / Date	Опис / Description

Ревизиони блок: / Revision block:

САОБРАЋАЈНИ ИНСТИТУТ ЦИП, д.о.о.
INSTITUTE OF TRANSPORTATION CIP ltd
Немањина 6; 11000 Београд; Србија
Тел: 011/3618-134; Факс: 011/3618-324; web site: www.sicip.co.rs

Организациона јединица:САОБРАЋАЈНИЦЕ/Organization unit:DEPARTMENT OF ROADS AND RAILWAYS

Responsible designer:
Драгана Јокановић, дипл.инж.грађ.
лиценца број: / license No.: 315 1404 03

Сарадници: / Associates:

Унутрашња контрола: / Internal control:
Милан Јелкић, дипл. грађ. инж.

Главни пројектант: / Chief designer:
Др Љиљана Милић Марковић, дипл.грађ.инж.

Руководилац организационе јединице:
Manager of organization unit:
мр Новица Стевановић , дипл.инж.грађ.

Инвеститор пројекта: / Investor:
" ИНФРАСТРУКТУРА ЖЕЛЕЗНИЦЕ СРБИЈЕ " А.Д.
/ " INFRASTRUCTURE RAILWAYS OF SERBIA " JSC
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Наручилац пројекта: / Employer: Joint Venture of
China Railway International Corporation Ltd. (CRIC)
No.10 Fuxing Road,Haidian District,Beijing
P.R China, 100844

China Communication Construction Company Ltd. (CCCC)
No.85 Deshengmenwai Street,Xicheng District,Beijing
P.R China, 100088

Објекат: /Structure:
ПРУГА БЕОГРАД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)
ДЕОНИЦА ПРУГЕ НОВИ САД - СУБОТИЦА - ДРЖАВНА ГРАНИЦА (КЕЛЕБИЈА)

BELGRADE - SUBOTICA - STATE BORDER (KELEBIA) RAILWAY LINE
SECTION : NOVI SAD - SUBOTICA - STATE BORDER (KELEBIA)

Део пројекта: / Part of Design:
2/2.6.2 ПРОЈЕКАТ ГОРЊЕГ СТРОЈА ЗА МОСТОВСКЕ КОНСТРУКЦИЈЕ ДУЖИНЕ ПРЕКО 40М-ДЕОНИЦА РУМЕНКА ИЗЛАЗ-ВРБАС НОВА ПУТНИЧКА УЛАЗ
2/2.6.2 DESIGN OF SUPERSTRUCTURE FOR BRIDGE STRUCTURES LONGER THAN 40M SECTION RUMENKA EXIT-VRBAS NOVA PASSENGER ENTRY

Цртеж: / Drawing:
ДИСПОЗИЦИЈА КОЛОСЕКА НА МОСТУ
СА СИГУРНОСНИМ ШИНАМАТИП ШИНЕ 60Е1
LAYOUT OF TRACKS WITH GUARD
RAILS ON BRIDGES TYPE 60 E1

Размера:
Scale:
1:20
1:10

Врста тех.док.: Type of tech.docum.: **ПЗИ** / DFC
датум:/date: **08.2021**
Цртеж бр./Drawing No.: 2020-250-CAO-2/2-6.2.7.3